THE JANUARY SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

THE NEW YORK MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

By President Henry Fairfield Osborn

THE SCIENCE PRESS

LANCASTER, PA.—GRAND CENTRAL TERMINAL, N. Y. CITY—GARRISON, N. Y.

Yearly Subscription $5.00 Single Copies 50 cents

THE SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

VOLUME XXVIII
JANUARY TO JUNE

NEW YORK
THE SCIENCE PRESS
1929

THE SCIENCE PRESS PRINTING COMPANY
LANCASTER, PA.

THE SCIENTIFIC MONTHLY

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THE NEW YORK MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

By Dr. HENRY FAIRFIELD OSBORN[1]
PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

On behalf of the fifty educational and scientific organizations of New York City, I extend a cordial welcome to the members of the American Association for the Advancement of Science and of the associated scientific societies. The national and local committees have agreed on a seven-day program, which will begin with Professor Bailey Willis's address on "Continental Genesis" on Wednesday, December 26, and will close on the evening of Tuesday, January 1, with Professor Harlow Shapley's address on "Galaxies of Galaxies." The intervening days and evenings will be chiefly devoted to topics in geology, physics, biology, chemistry and anthropology in the order named. Each address will be accompanied by an evening reception in the corresponding department of the American Museum of Natural History. Following the admirable precedent set by the British Association, these evening addresses will be of a semi-popular character destined to attract and stimulate the rapidly growing interest in science manifested in the city of New York and throughout the United States and Canada. The leading motif of this science week program, however, is to offset some of the extreme specialization of the present day by a more general prospectus of the unity and harmony of various sciences such as prevailed in the unified spirit of the great founders of the association eighty-five years ago. Special honor should be done on December 27 to Louis Agassiz on this centenary of his epoch-making glacial theory.

Visiting scientists will be impressed with the really marvelous developments to be witnessed in the fifty institutions which are extending their hospitality, the large majority of which were unknown and unthought of in the year 1888, when President Seth Low was called to be the head of Columbia University, and President Eliot, of Harvard University, delivered the leading inaugural address, in which he commented with some sarcasm on the violent contrast between the material wealth and affluence of the city of New York and the poverty and backwardness of its scientific, educational and literary spirit. A complete not only metamorphosis but metapsychosis has taken place since that only too truthful inaugural address of President Eliot, for New York has become one of the leading scientific and

[1] Assisted by Helen Ann Warren, assistant local secretary. Prepared at the general headquarters of the American Association for the Advancement of Science, Education Hall, American Museum of Natural History, 77th Street and Central Park West, New York City.

DR. HENRY FAIRFIELD OSBORN

PRESIDENT OF THE AMERICAN MUSEUM OF NATURAL HISTORY AND RESEARCH PROFESSOR OF ZOOLOGY, COLUMBIA UNIVERSITY. DR. OSBORN IS PRESIDENT OF THE AMERICAN ASSOCIATION.

—From the American Museum of Natural History

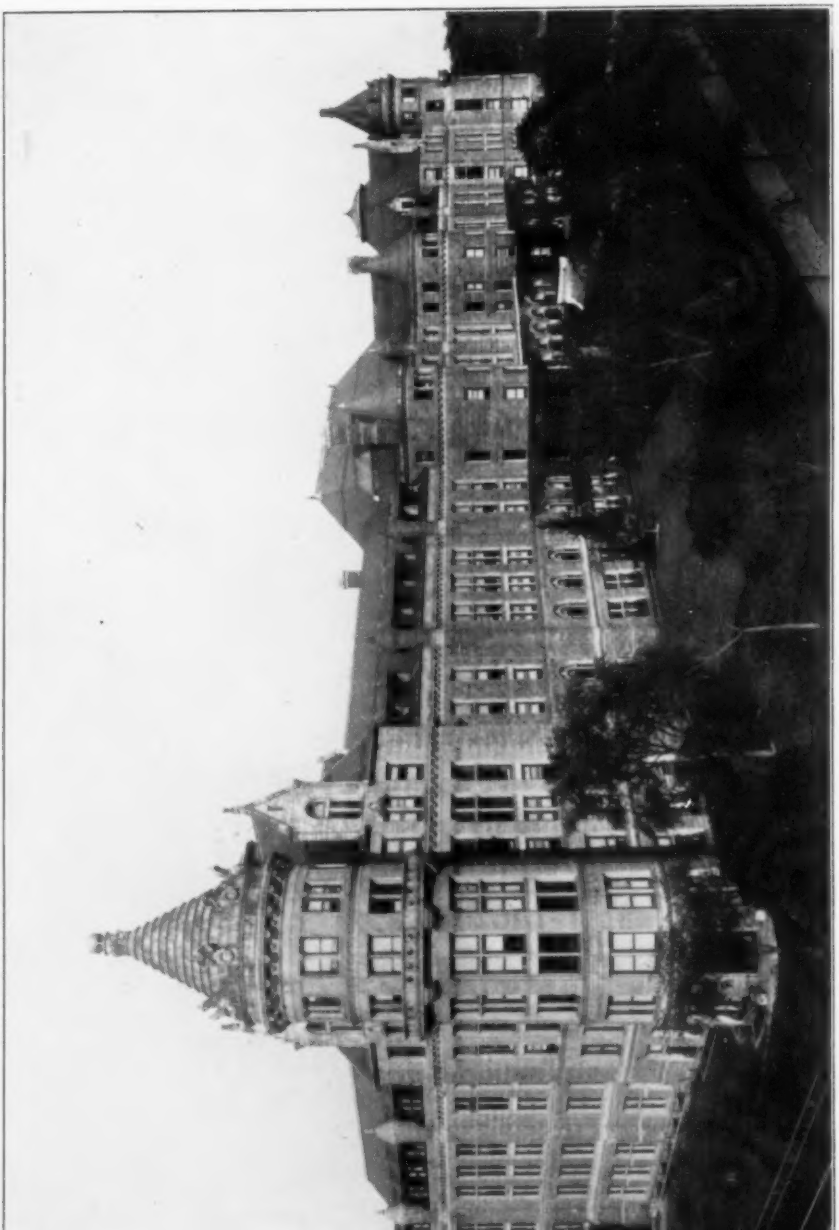
DARWIN HALL
THE AMERICAN MUSEUM OF NATURAL HISTORY.

educational centers of the world. It has attracted leading workers not only from the United States to its institutions of pure and applied science but from great centers of learning and research abroad. From being purely metropolitan it has become truly cosmopolitan.

During the past twenty-eight years the local government of the city of New York has led all cities of the world in building up great institutions of art, science and literature, so that by a few giant strides New York has overtaken and in some instances has surpassed the work of centers of learning in the great capitals of Europe. A delightful feature of Science Week will be the Sunday evening reception at the splendid Metropolitan Museum of Art by the mayor of the city and the trustees of the museum. Another is the Sunday afternoon Philharmonic-Symphony concert, led by the famous conductor, Mengelberg, and donated especially to the visiting members of the association through the generosity of Mr. Clarence H. Mackay, president of the Postal Telegraph-Cable Company. On Sunday morning leading preachers in thirty-eight pulpits of all denominations have been invited by the president to address the public and visitors to New York during this great science week on the subject "Nature and Religion."

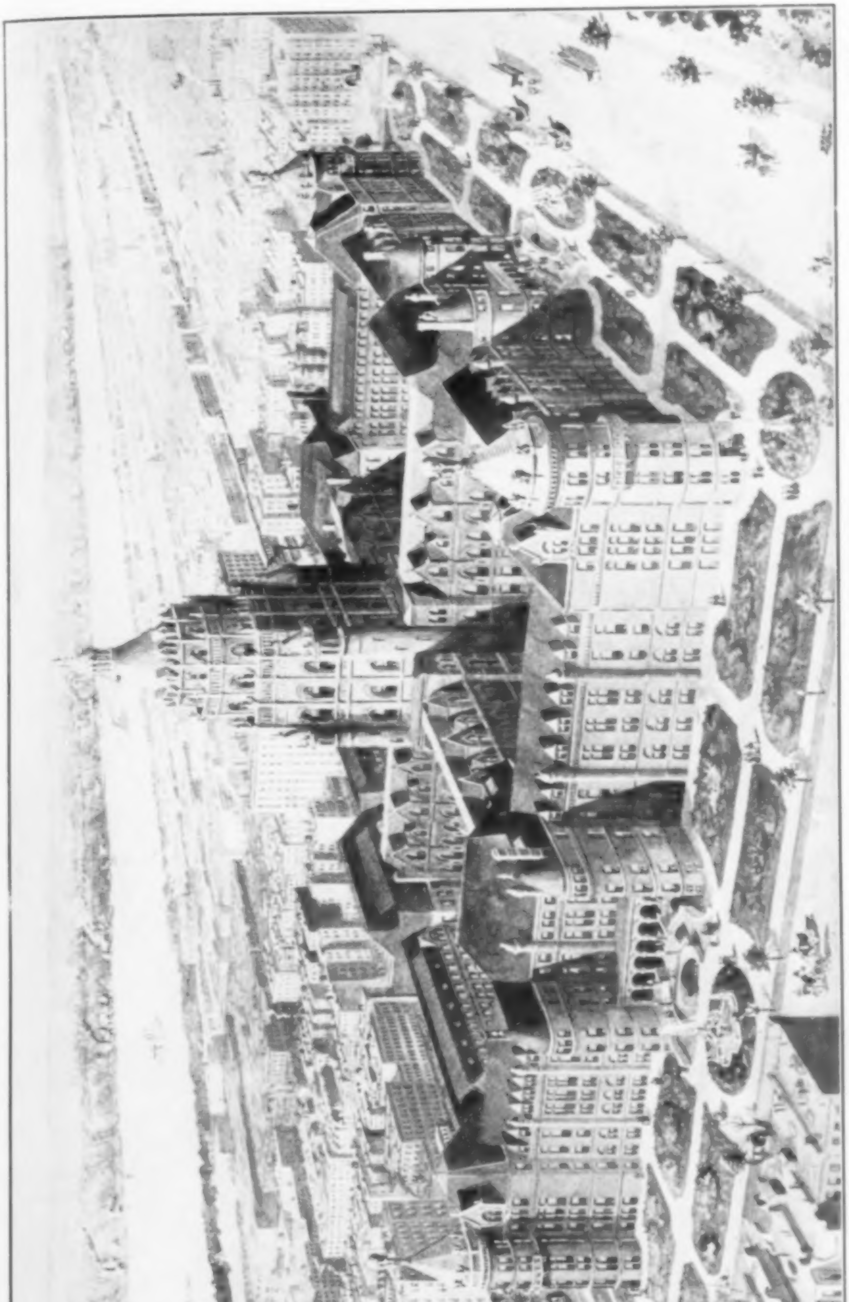
New York City Welcomes the Association

New York City welcomes the American Association for the Advancement of Science for the fifth time. Fifty scientific and educational institutions, many of them newly housed in splendid buildings, others still the familiar landmarks of past meetings, except for innovations in equipment, await the inspection of their out-of-town guests.



—*From the American Museum of Natural History*

THE AMERICAN MUSEUM OF NATURAL HISTORY



—*From the American Museum of Natural History*

THE COMPLETED AMERICAN MUSEUM OF NATURAL HISTORY

AS DESIGNED BY THE ARCHITECT IN 1891

DR. ARTHUR A. NOYES

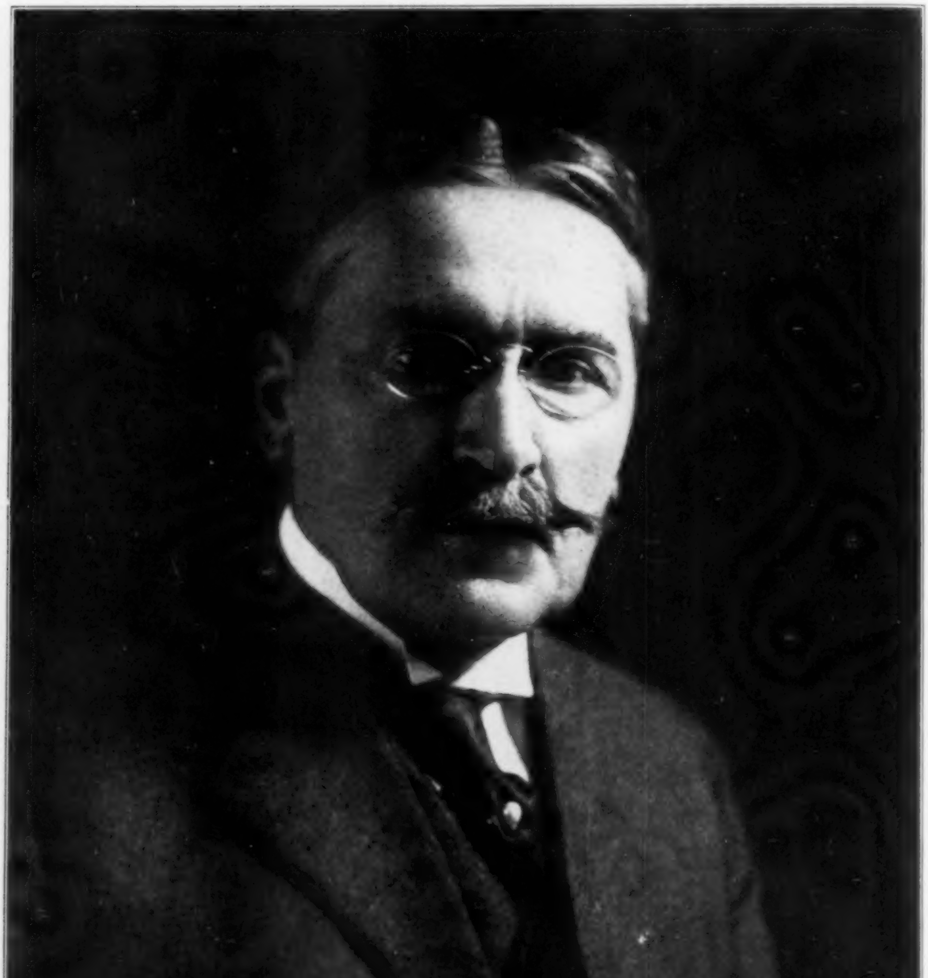
Director of the Gates Chemical Laboratory, California Institute of Technology.
Dr. Noyes is the retiring president of the American Association.

THE LIBRARY OF COLUMBIA UNIVERSITY

The schools, universities, museums and laboratories of a nation represent its intellectual vigor as cultivated by just such organizations as the American Association and by the individuals who compose its membership. New York City because of its size and prosperity is the location of a fair share of these institutions of the United States. In fact, members who remember the brownstone city during the sultry August meeting of 1887, when S. P. Langley was president, and those who rode around the growing city of 1900 in horse-cars to hear President R. S. Woodward and his contemporaries, as well as the elevated travelers of December, 1906, who listened to President William H. Welch, and the subway straphangers of December, 1916, when Charles R. Van Hise was president, will be amazed at the city's growth in scientific institutions as well as in scientific and commercial skyscrapers. Notable among the newer skyscrapers, for instance, is the medical center of Columbia University and the Presbyterian Hospital, located at 168th Street and Broadway on a hilltop and commanding the Hudson River for miles up and down stream.

There have been many changes on the Columbia University campus in the twelve years since the association last met there. Among these the Physics Building, the Chemistry Building, School of Business, Barnard Hall and the recently completed Teachers College halls offer the latest sort of university and laboratory equipment.

At the American Museum, where all the evening general sessions will be held, a greatly increased collection of animal and mineral specimens, arranged in strikingly effective natural habitat groups, invite examination. During the past twelve years the museum authorities have worked out the wall alcove display method with some really beautiful results. Crowds of interested children in the Indian, mammal, fish and bird halls testify to the real value of the natural background method, while their



DR. MICHAEL I. PUPIN

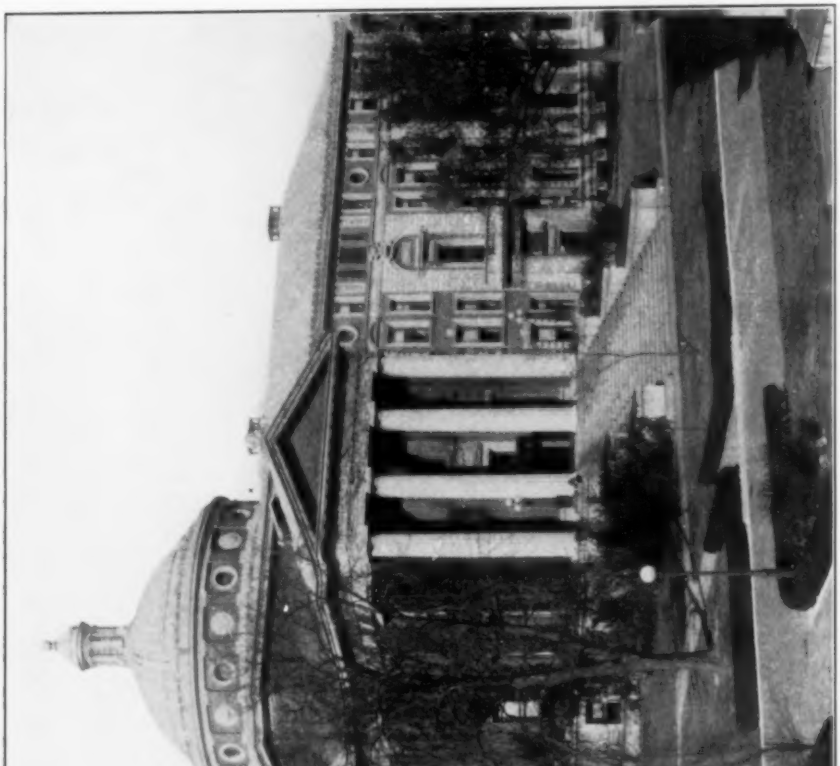
PROFESSOR OF ELECTROMECHANICS, COLUMBIA UNIVERSITY. DR. PUPIN IS HONORARY CHAIRMAN OF THE LOCAL COMMITTEE AND WAS PRESIDENT OF THE AMERICAN ASSOCIATION IN 1925.

THE NEW PHYSICS BUILDING OF COLUMBIA UNIVERSITY

elders find food for speculation in the Hall of the Age of Man, the comparative anatomy exhibits, the recently enlarged Dinosaur and Reptile Halls, the Darwin Hall, the Forestry and Oceanic Halls, the Geological, Astronomical and Anthropological exhibits and the Hall of Jewels. Color and form are vital elements in nature and in the art which simulates nature. These have been particularly studied at the American Museum of late years through the inspiration of Carl Akeley and his friends until the business of taxidermy has added the art of painting and sculpture to its model mounting and has become a living merger of art and science.

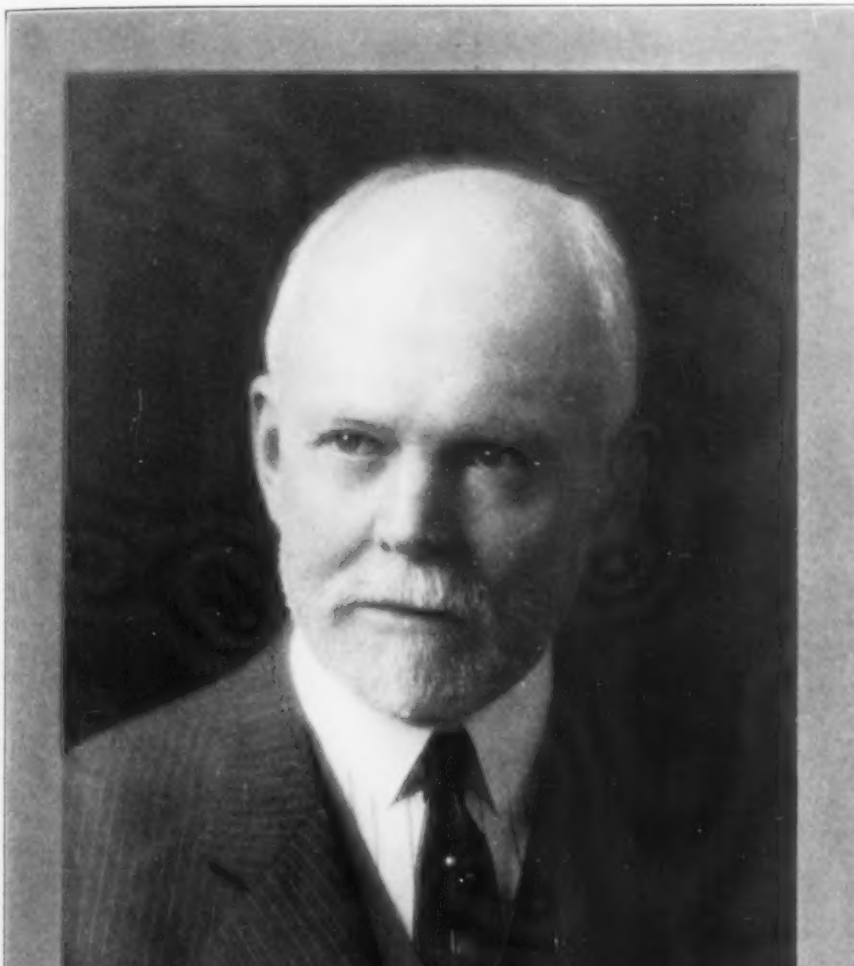
Beside the meetings at Columbia and the American Museum some of the sessions of the association and its associated societies will take place at the United Engineering Societies Building on West 40th Street. One or two will occur at the New York Academy of Medicine's quarters at 103rd Street and Fifth Avenue, while there will also be hotel meetings and various excursions. Photographs of some of the places to be visited accompany this article.

Among the institutions acting as hosts to the visiting scientists are: The American Chemical Society, The American Geographic Society, The American Institute of Electrical Engineers, The American Institute of Mining and Metallurgical Engineers, The American Museum



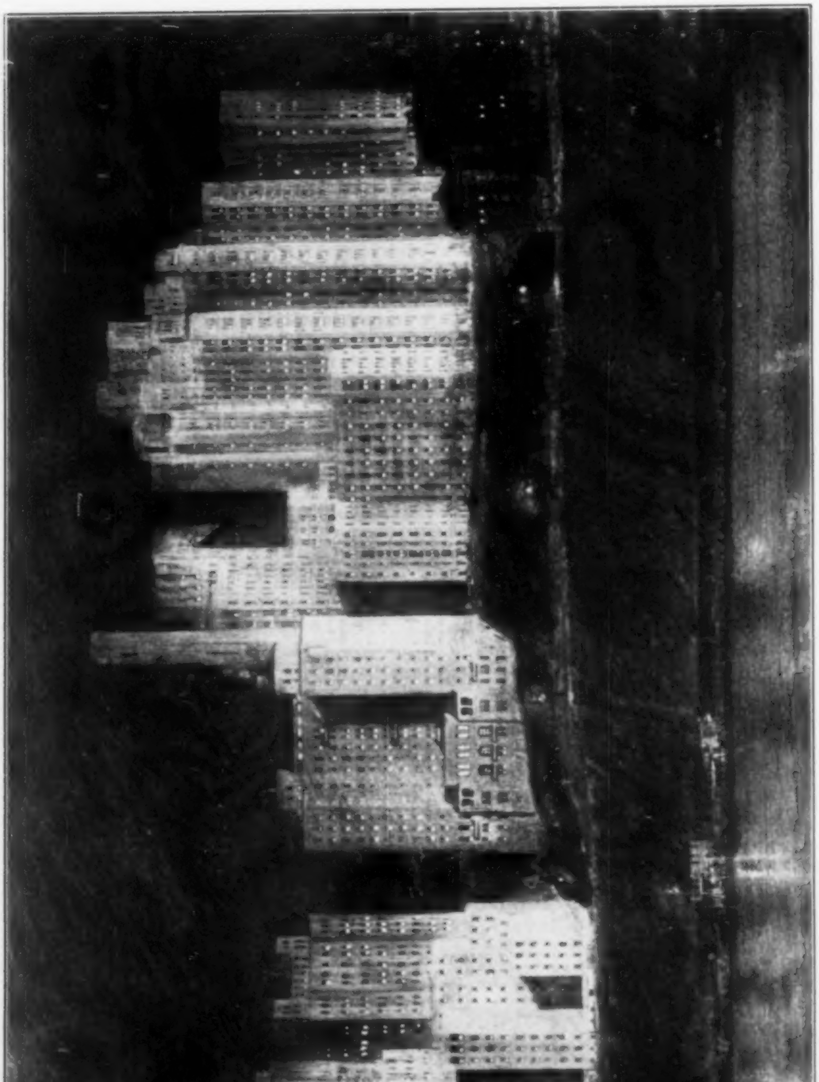
BUILDINGS OF COLUMBIA UNIVERSITY

EARL HALL, IN THE CENTER, WITH THE BUILDINGS FOR MINING AND ENGINEERING. BARNARD COLLEGE IS IN THE BACKGROUND.



DR. E. B. WILSON

Emeritus professor of zoology, Columbia University. Dr. Wilson was president of the American Association in 1914.



—*Underwood & Underwood*

THE MEDICAL CENTER OF COLUMBIA UNIVERSITY

FORMALLY DEDICATED TO RESEARCH, TEACHING AND CARE OF THE SICK, ON OCTOBER 12, 1928.

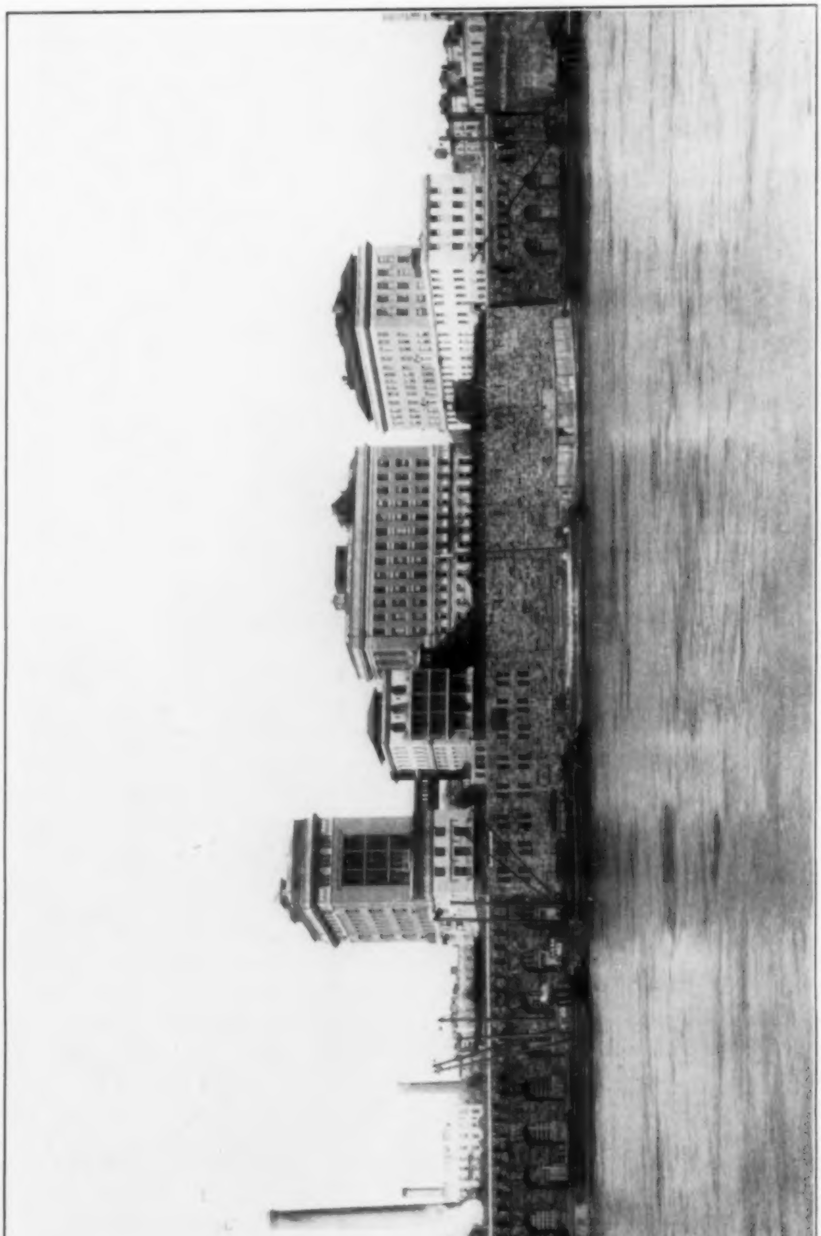
THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

of Natural History, The American Society of Civil Engineers, The American Society of Mechanical Engineers, The American Telephone and Telegraph Company and the Aquarium.

Barnard College, The Biological Laboratory of the Long Island Biological Association, The Brooklyn Botanic Garden, The Brooklyn Institute of Arts and Sciences, The Casa Italiana of Columbia University, The Chamber of Commerce of the State of New York, The Chemical Foundation, The College of the City of New York, The College of Physicians and Surgeons, Columbia University, Cooper Union for the Advancement of Arts and Sciences and Cornell University Medical College.

The Engineering Foundation, The Eugenics Record Office of the Carnegie Institution of Washington, Fordham University, The General Electric Company, The Hispanic Society of America, The Horace Mann School, The Hotel Association of New York, The International Education Board, The International House, The Lincoln School, The Long Island College Hospital, The Merchants Association of New York, The Metropolitan Museum of Art, The Museum of the American Indian, The Museum of the State of New York and the Museums of the Peaceful Arts.

The New York Academy of Medicine, The New York Academy of Sciences, The New York Botanical Garden, The New York Department of Health, The New York Historical Society, The New York Post-Graduate Medical School and Hospital, The New York Telephone Company, New York University, The New York Zoological Society, the Postal Telegraph-Cable Company, The Radio Corporation of America, The Rockefeller Institute for Medical Research, The Russell Sage Foundation, The Station of Experimental Evolution of the Carnegie Institution of Washington, Stevens Institute of Technology, Teachers College, The University of the State of New York, the Western Electric Company and The Western Union Telegraph Company.



THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

DR. SIMON FLEXNER
DIRECTOR OF THE LABORATORIES, THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH.
DR. FLEXNER WAS PRESIDENT OF THE AMERICAN ASSOCIATION IN 1920.

THE BOYCE-THOMPSON INSTITUTE FOR PLANT RESEARCH

Excursions, mentioned above, will visit the Aquarium, where the strangest fish in the world and the most common food fish swim peacefully in the walls which once echoed to Jenny Lind's sweetest notes. The most recent acquirements at the Aquarium come from the Galapagos Islands and are quite extraordinary. The Zoo, with its realistic jungle and Arctic backgrounds, will be visited, as will be the greenhouses of the New York and Brooklyn Botanic Gardens, the Children's Museum of Brooklyn and the Western Electric Laboratory.

Besides these scientific excursions there remain the old-time haunts of Peter Stuyvesant's, Alexander Hamilton's and Grover Cleveland's city, Fraunce's Tavern, Trinity Church, St. Paul's Chapel, Battery Park, the Jumel Mansion, where Aaron Burr lived, the Gracie Mansion, the Dyckman farmhouse and Grant's tomb. There is the bustling port of New York to watch; the rambunctious Stock Exchange; the East Side city of immigrant Jews, Armenians, Italians; the Russian quarter; Greenwich Village; the German midtown blocks of the East Side; the fashionable city; the coffee district, silk district, paper district, toy district, department store district; and Broadway, where opera, tragedy, farce, vitaphone, movietone and the flea circus elbow each other for ten crowded blocks. There is the alarming new Paramount Building to marvel at, the peaceful paths of Central Park for a brisk walk and the impressive American Wing of the Metropolitan Museum of Art, where American history unfolds itself through the hospitality of American homes. An old visitor to New York will never tire of crossing Brooklyn Bridge afoot at sunset, nor regret a visit to the top of the Woolworth Tower to view a skyline that has changed vastly in the last three years.

There are all these places and more to see in the city that is for the moment completed. Then there is the city under construction. Here rises the Cathedral of St. John the Divine, building on the medieval plan and containing an already famous sports window, where the everyday college football player, crewman, polo player and hurdler stand perpetuated in Cathedral glass. Westward the Hudson River suspension bridge rears its great skeleton on the New York and Jersey shores, though the intervening span is still imaginary. Eastward the Eighth Avenue subway continues to get

DR. JOHN M. COULTER
THE BOYCE-THOMPSON INSTITUTE. DR. COULTER WAS PROFESSOR OF BOTANY FROM 1896–1925 AND WAS PRESIDENT OF THE AMERICAN ASSOCIATION IN 1919.

THE METROPOLITAN MUSEUM OF ART

THE ROMAN COURT
METROPOLITAN MUSEUM OF ART.

itself built while the city marches atop its excavations. All about the town the amusing spectacle of building from the top down goes on while the crowds hurry to work happy because it is Christmas and high-spirited because the air is crisp and so much is going on.

American Association Program

A great deal will be going on for the American Association. The association meets this year with the largest enrolment in its history. Its more than 17,000 members represent every state in the Union and all parts of the Dominion of Canada. Every field of science from the broadest aspects to the most minute and detailed sort of investigation has its place on the program, while general sessions have been planned to synchronize the whole, to bring back some measure of the advantages of the old-fashioned all-around scientist over his necessarily specialized successor, and to give each worker a glimpse of all science: in its relation to his work, in its value as a method of thought and in its extreme importance to the daily problems of civilization.

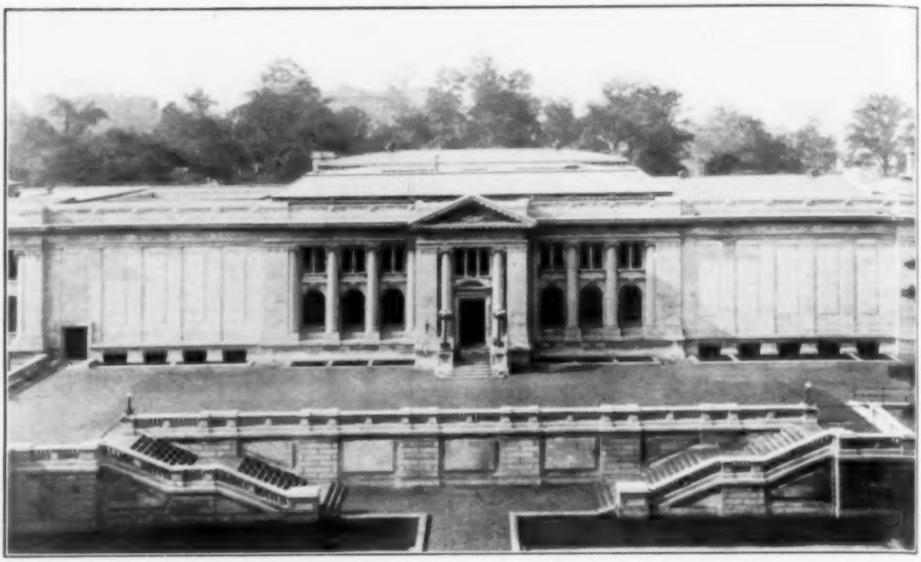
The president, in the midst of his extreme occupation with the pressing daily affairs of his great museum and his extensive researches, has given a great deal of time and consideration to this general program and has arranged that every branch of scientific endeavor will have its special open session for non-technical addresses. These will occur unless otherwise noted in the auditorium of the American Museum of Natural History and will be followed by an informal reception in Education Hall and an inspection of the exhibition halls closely related to the subject under discussion.

The program of general sessions is as follows:

THURSDAY, DECEMBER 27, 1928

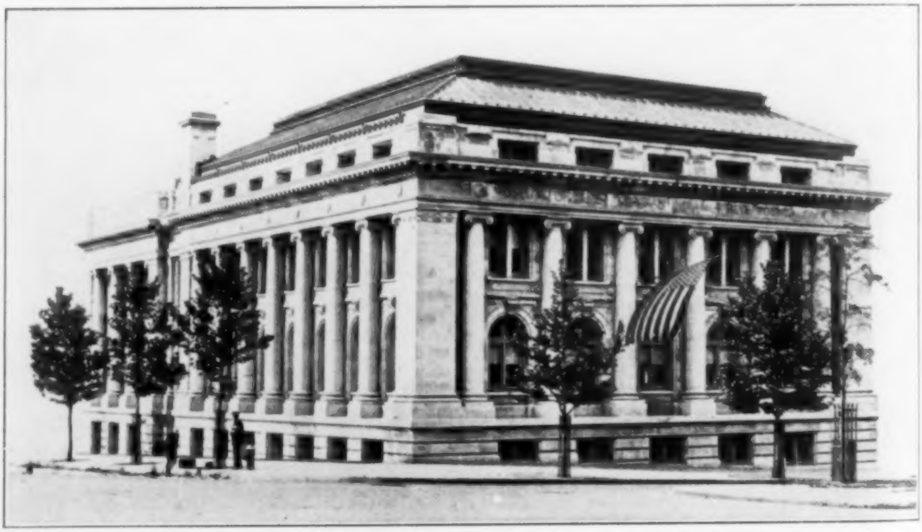
Afternoon

Geologic Symposium, "The Centenary of the Glacial Theory." Addresses by Drs. Osborn

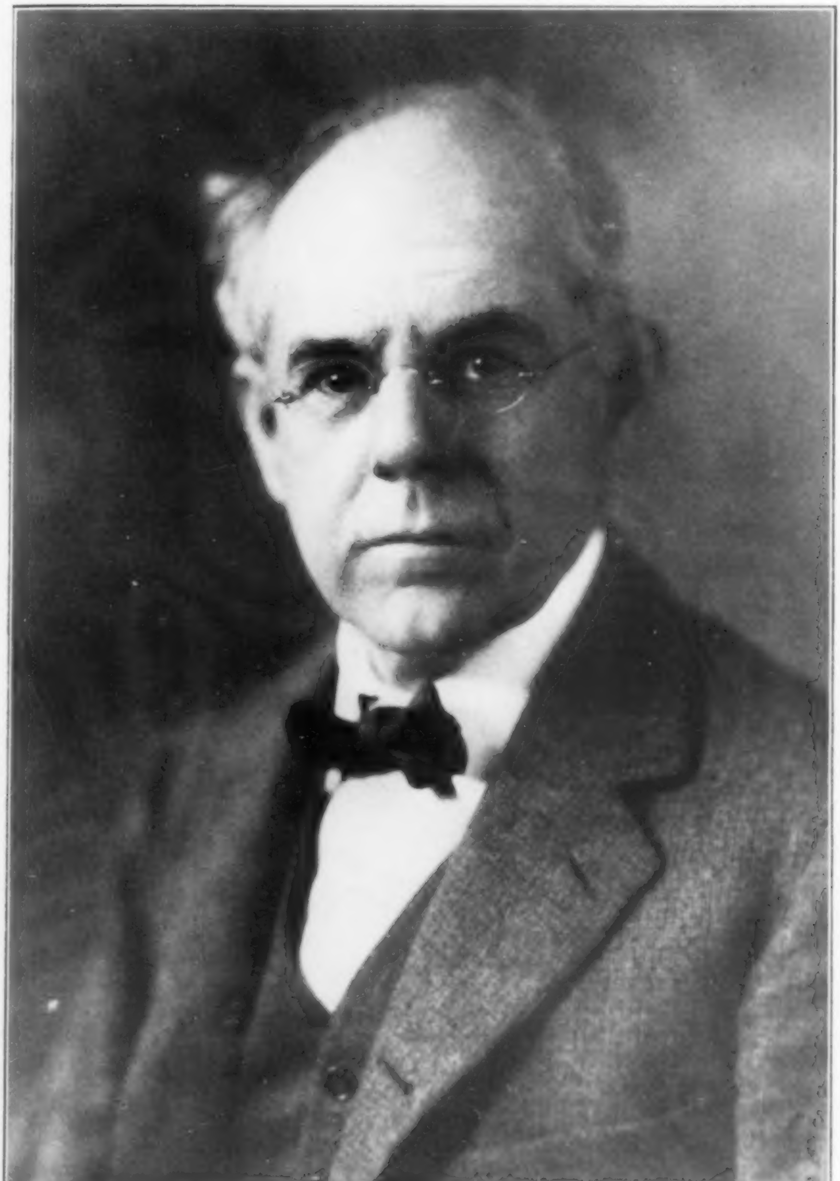


—*Hispanic Society of America*

THE BUILDING OF THE HISPANIC SOCIETY OF AMERICA

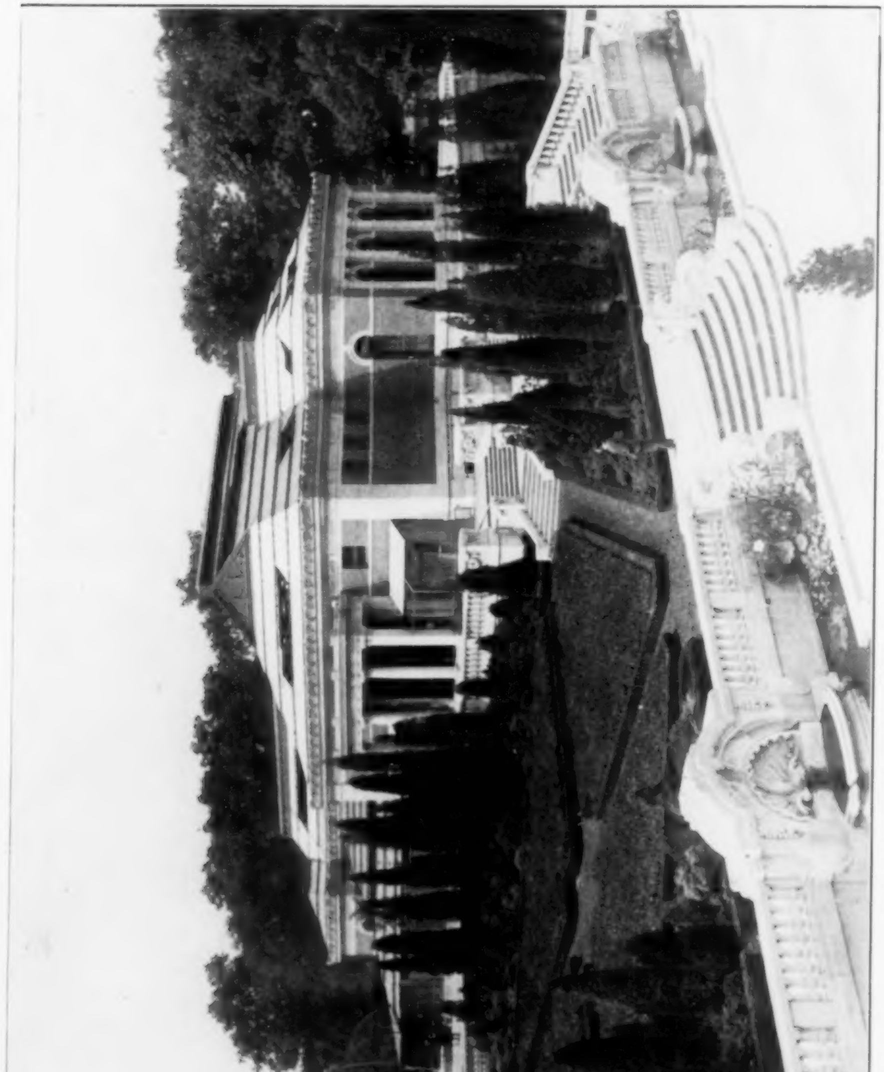


THE MUSEUM OF THE AMERICAN INDIAN
HEYE FOUNDATION.

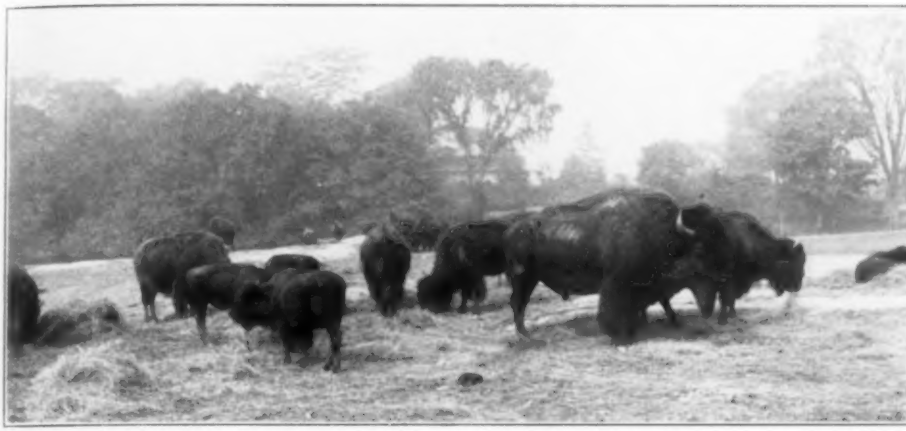


DR. J. McKEEN CATTELL

EDITOR OF *Science* AND THE SCIENTIFIC MONTHLY, FORMERLY HEAD OF THE DEPARTMENTS OF PSYCHOLOGY, ANTHROPOLOGY AND PHILOSOPHY, COLUMBIA UNIVERSITY. DR. CATTELL IS CHAIRMAN OF THE EXECUTIVE COMMITTEE OF THE AMERICAN ASSOCIATION AND WAS PRESIDENT IN 1924.



THE NEW YORK ZOOLOGICAL PARK



A HERD OF BISON
IN THE NEW YORK ZOOLOGICAL PARK.

("The Influence of the Glacial Age on the Pre-History of Man"), Reeds ("Weather and Glaciation"), Antevs ("New Maps of Pleistocene Glaciation"), Daly ("Swinging Sea Level of the Ice Age"), Hobbs ("Climatic Zones and Periods of Glaciation") followed by short discussions.

At 4:30 Dr. Frank Leverett will deliver an address on "Glaciations of the Northern Hemisphere."

Evening

Addresses of Welcome at 8 p. m. Mayor James J. Walker and prominent New Yorkers will welcome the association to New York.

At 8:30 Dr. Charles P. Berkey, of Columbia University, will speak on "Recent Discoveries in the Geology of Mongolia," touching on the work done by the Central Asiatic Expeditions of the American Museum.

FRIDAY, DECEMBER 28, 1928

Afternoon

Sixth annual Josiah Willard Gibbs lecture of the American Mathematical Society. Professor G. H. Hardy, of the University of Oxford, will speak on "An Introduction to the Theory of Numbers." 4:30 p. m., at the Casa Italiana.

The Canti film, depicting the behavior of tissue cells *in vitro*, will be shown by Dr. C. A. Kofoid, of the University of California, in the Horace Mann auditorium at 4:30 p. m.

Evening

Seventh annual Sigma Xi lecture will be given under the auspices of the American Association, the American Physical Society and the Society of the Sigma Xi by Dr. Arthur H. Compton, of the University of Chicago, on "What is Light?"

SATURDAY, DECEMBER 29, 1928

Afternoon

General anthropological address by Dr. Franz Boas, of Columbia University, at 4:30, in the Duplex Assembly Room of the American Museum. Subject, "Migrations of Asiatic Races and Cultures to North America."

General showing of American Museum films in the Auditorium at 4:30, including "Simba" and other Martin Johnston films, Dr. Robert Cushman Murphy's "Sea Birds," Dr. Roy Chapman Andrews' "Dinosaurs' Eggs," Dr. Roy Miner's "Under the Sea" and Carl Akeley's "Gorillas."

Symposium on "Salary Adequacy of Academic Families," under the direction of the Committee of One Hundred on Scientific Research, at Columbia University.

Evening

General biologic address by Professor William Morton Wheeler, of Harvard University, "New Tendencies in Biologic Theory."

MONDAY, DECEMBER 31, 1928

Evening

Retiring presidential address of Dr. Arthur A. Noyes, of the California Institute of Technology, on "The Story of the Elements."

TUESDAY, JANUARY 1, 1929

Afternoon

Address in Astronomy by Professor H. H. Turner, F.R.S., of Oxford University, who will represent the British Association at the sessions.

DR. GEORGE B. PEGRAM
PROFESSOR OF PHYSICS, COLUMBIA UNIVERSITY, CHAIRMAN OF THE LOCAL COMMITTEE.

DR. SAM F. TRELEASE
ASSOCIATE PROFESSOR OF BOTANY, COLUMBIA UNIVERSITY, SECRETARY OF THE COUNCIL AND OF THE LOCAL COMMITTEE.

Evening

Dr. Harlow Shapley, of the Harvard Observatory, on "The Galaxies of Galaxies."

Besides these general sessions there will be a number of joint sessions of particular interest to large groups. Among these are the address of Dr. Bailey Willis before the Geological Society on Wednesday evening; the joint meeting of Section G and the Botanical Society of America on Friday afternoon at Teachers College; the joint session of the American Physical, Astronomical and Meteorological Societies with Sections B and D on the same afternoon at the American Museum; the Symposium of the American Society of Naturalists on Saturday afternoon at the American Museum; and the Synthetic Luncheon of Sections C, K and N with the American Institute of the City of New York. This luncheon will take place at the Hotel Commodore at one o'clock on Saturday afternoon. Colonel Marston T. Bogert, of Columbia University, will

DR. H. H. TURNER
SAVILIAN PROFESSOR OF ASTRONOMY, OXFORD UNIVERSITY, REPRESENTING THE BRITISH ASSOCIATION AT THE NEW YORK MEETING.

THE NEW YORK BOTANICAL GARDEN
MUSEUM BUILDING.

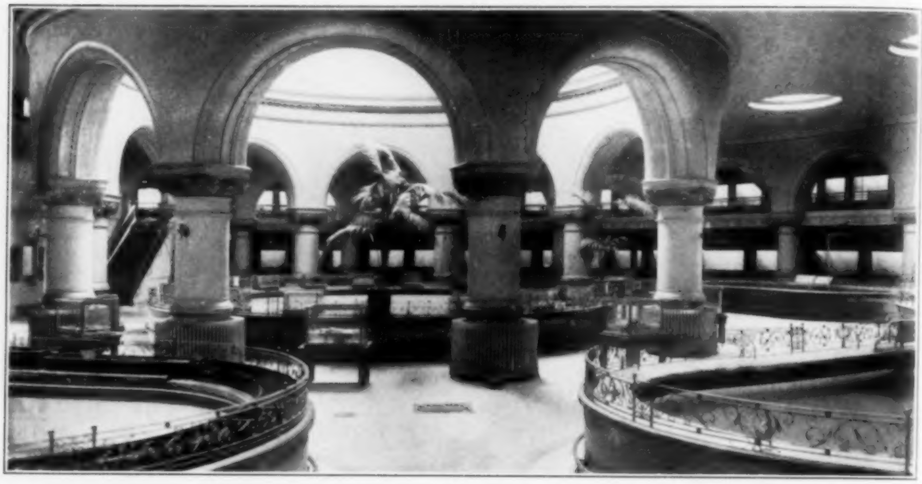
preside. Dr. Edwin E. Slosson, of Science Service, will discuss "Effects of Synthetic Organic Chemistry on our National Life." Dr. Roger Adams, of the University of Illinois, will discuss "Recent Contributions of Synthetic Organic Chemistry to Medicine." Dr. Charles H. Herty, adviser of the Chemical Foundation and past-president of the Synthetic Organic Chemicals Manufacturers Association, will speak on "Recent Contributions of Synthetic Organic Chemistry to Industry."

The science exhibition, pertinent to all these sessions because of its extensive collection of apparatus and scientific publications, will be as usual under the charge of Major H. S. Kimberly, of the national office. It will be held in the gymnasium of Columbia University and will be well worthy of a visit from workers in any field. Individual societies will in addition have their special exhibits near or in their meeting rooms.

The sixth annual award of the American Association prize of \$1,000 will be announced at the close of the meeting. This prize, given by an anonymous donor, is awarded to the author of a noteworthy contribution to science. Any paper presented at the meeting is eligible, whether its author is a member of the association or merely of one of the societies. The announcement of the award committee's selection will be made through the association's news service. Full reports of the daily progress of the sessions will also be supplied to the press of the United States and the world by the news service. The news room will be located in the School of Journalism of Columbia University, where originals and abstracts of papers will be available to the press.

ATTRACTIVE SUNDAY PLANS

Sunday occurs in the middle of the meeting week and will be a time of recreation of a most attractive sort. In the morning excursions to various places of interest will be conducted, as announced by the Entertainment Committee in the program and at the registration offices. The clergy of New York City, whose predecessors formed a substantial percentage of the early membership of the association, have been asked to recognize the present meeting in special sermons. The topic of "Nature and Religion" has been suggested to them by the president of the association as preferable to the more usual and sometimes



THE NEW YORK AQUARIUM

antagonistic "Science and Religion" or "Science and Theology." Every religious denomination was included in this invitation to extend Sunday morning hospitality to the visitors. Many interesting sermons are expected.

On Sunday afternoon the special concert of the Philharmonic-Symphony Society takes place at Carnegie Hall. Every registrant is entitled to a complimentary ticket, which may be obtained at the registration booths. Any seats which are unclaimed by Saturday noon will be available for accompanying members of families, but as the capacity of the hall is limited to 2,700 it was thought wise to allow the first reservations only to members. Out-of-town members are especially urged not to miss this opportunity of hearing one of the finest orchestras of the country in its own hall. The program, with Mengelberg conducting, will be as follows:

Liszt, Prelude.

Tschaikowsky, Adagio, Andante Cantabile.

Wagner, Wotan's Farewell from Die Walkure.

INTERMISSION

Strauss, Ein Heldenleben.

On Sunday evening the trustees of the Metropolitan Museum of Art will set aside long-established precedents and give a reception to the members of the American Association. Guests will enter the building by the park entrance and will proceed through the galleries to the Fifth Avenue gallery, where the reception will take place. There will be music throughout the evening. Every person who registers will receive an invitation to this reception and will thereby acquire a most unusual opportunity of viewing the treasures of the museum.

ENTERTAINMENT PROGRAM

There will be the usual society luncheons and dinners, managed in each case by the society concerned. There will also be a general social program, announced by the entertainment committee as follows:

DAILY EVENTS

Luncheon—In the Flying Bird Hall of the American Museum. 60 cents.

Afternoon Tea—At 4:30 o'clock in the Grace Dodge Rooms of Teachers College, Philosophy Hall of Columbia University, and Education Hall of the American Museum, through the courtesy of the university and museum officers.

Visitors Welcome—Aquarium, Bell Telephone Laboratories, Boyce Thompson Institute, Children's Museum and Brooklyn Botanic Garden, New York Botanical Garden, New York Historical Society, Long Island College Hospital,

College of Physicians and Surgeons, New York Zoological Park, Radio Corporation of America, Russell Sage Foundation. Eugenics Record Office and Station of Experimental Evolution of the Carnegie Institution at Cold Spring Harbor, Rockefeller Institute for Medical Research.

THURSDAY

Reception by the trustees of the American Museum of Natural History, 9:30 p. m., in the Hall of the Age of Man. Invitations will be distributed at registration booths. The entire museum will be open for inspection. There will be music and light refreshments.

FRIDAY

Informal evening reception at American Museum, following Sigma Xi address.

SATURDAY

Afternoon tea at the Museums of the Peaceful Arts, 24 West 40th Street. Invitations may be obtained at the registration booths.

Informal evening reception at American Museum following general biologic address.

DR. P. W. BRIDGMAN
PROFESSOR OF MATHEMATICS AND NATURAL PHILOSOPHY, HARVARD UNIVERSITY; CHAIRMAN OF THE SECTION OF PHYSICS.

DR. RAY. C. ARCHIBALD
PROFESSOR OF MATHEMATICS, BROWN UNIVERSITY; CHAIRMAN OF THE SECTION OF MATHEMATICS.

SUNDAY

Excursions as announced.

Church services as announced.

Afternoon concert by Philharmonic-Symphony Society at Carnegie Hall. Tickets can be obtained at registration booths.

Evening reception at Metropolitan Museum of Art.

MONDAY

Informal reception following Dr. Arthur A. Noyes' retiring presidential address, Education Hall, American Museum.

TUESDAY

Informal reception at American Museum, following astronomic address.

MEETING PLACES

Meeting places for the daily sessions of the sections and societies have been announced by Chairman Pegram, as follows:

American Museum: American Anthropological Association, American Folk-Lore Society, American Nature Study Society, American Society of Naturalists, Geological Society of

THE COLLEGE OF THE CITY OF NEW YORK

America, Mineralogical Society of America, Palaeontological Society of America, Sections E and H, Society of Economic Geologists.

Barnard College: American Mathematical Society, Mathematical Association of America, Section A.

Fayerweather Hall, Columbia University: American Psychological Association, Section I.

Metropolitan Museum of Art: American Philological Society, Archaeological Institute of America, College Art Association, Metric Association.

Physics Laboratories, Columbia University: American Astronomical Society, American Meteorological Society, American Physical Society, Sections B and D, Society of the Sigma Xi.

Schermerhorn Hall, Columbia University: American Psychological Association, Section I.

School of Business, Columbia University: Metric Association.

School of Mines, Columbia University: Linguistic Society of America.

American Geographic Society: Association of American Geographers.

Teachers College of Columbia University: American Association of Economic Entomologists, American Fern Society, American Microscopical Society, American Phytopathological Society, American Society of Agronomy, American Society of Foresters, American Society for Horticultural Science, American Society of Parasitologists, American Society of Plant Physiologists, American Society of Zoologists, Association of Official Seed Analysts, Botanical Society of America, Ecological Society of America, Entomological Society of America, Genetics Sections, Geneticists Interested in Agriculture, Gamma Sigma Delta, Phi Sigma Biological Research Society, Potato Association of America, National Council of Geography Teachers, Sections F, G, O and Q, Sullivant Moss Society.

Casa Italiana of Columbia University: American Association of University Professors.

DR. C. E. KENNETH MEES
DIRECTOR OF RESEARCH AND DEVELOPMENT, EASTMAN KODAK LABORATORIES; CHAIRMAN OF THE SECTION OF CHEMISTRY.

DR. J. S. PLASKETT
DIRECTOR OF THE DOMINION ASTROPHYSICAL OBSERVATORY, VICTORIA, B. C., CANADA; CHAIRMAN OF THE SECTION OF ASTRONOMY.

The general local committee, which has worked under President Osborn, Chairman Pegram and Secretary Trelease, consists of:

Henry Fairfield Osborn, *president of the association;* American Museum of Natural History.

Michael I. Pupin, *honorary chairman;* Columbia University.

George B. Pegram, *general chairman and chairman of the special committee on meeting places;* Columbia University.

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J. McKeen Cattell, *chairman of the association executive committee;* Science Press.

Fred H. Smyth, *local treasurer;* American Museum of Natural History.

Helen Ann Warren, *assistant secretary;* American Museum of Natural History.

Walter H. Eddy, *chairman of the special committee on luncheons.*

Harold A. Fales, *chairman of the special committee on exhibition.*

James T. Grady, *chairman of the special committee on news service.*

Donald E. Lancefield, *chairman of the special committee on local transportation.*

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DR. R. L. SACKETT

DEAN OF THE SCHOOL OF ENGINEERING AND DIRECTOR OF THE ENGINEERING EXPERIMENT STATION, PENNSYLVANIA STATE COLLEGE; CHAIRMAN OF THE SECTION OF ENGINEERING.

DR. C. A. MOOERS

DIRECTOR OF THE TENNESSEE EXPERIMENT STATION; CHAIRMAN OF THE SECTION OF AGRICULTURE.

Long Island College Hospital, *Dean Adam M. Miller.*

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Western Union Telegraph Company, *Vice President G. M. Yorke.*
Yale University and the Peabody Museum, *Professor Richard S. Lull.*

In placing this program and these meeting arrangements at the disposal of the members, the officers of the association have worked in the hope that every member registering for the sessions will make full use of this opportunity of realizing the fourfold objects of the association. When applied to the individual member these are briefly: (1) to promote intercourse among scientific workers in different parts of America, and thereby to aid knowledge of each other's methods, ideas, problems and personality; (2) to provide familiarity with other scientific societies and institutions, through cooperation and personal inspection; (3) to give a stronger, more general impulse and more systematic direction to scientific research, through the exchange of ideas and the establishment of a definite time and place of publication; (4) to procure for the labors of scientific men increased facilities and a wider usefulness. This last object is particularly well accomplished in a city

like New York, where public interest is widely aroused and where the leaders of commerce and industry can be brought face to face with the men whose inventions and painstaking investigations make possible a large measure of the material as well as intellectual prosperity of the country.

DR. FRANK LEVERETT
LECTURER IN GLACIAL GEOLOGY, UNIVERSITY OF MICHIGAN; CHAIRMAN OF THE SECTION OF GEOLOGY AND GEOGRAPHY.

HISTORY OF THE AMERICAN ASSOCIATION

The American Association for the Advancement of Science is a national organization of scientific workers with permanent headquarters in the Smithsonian Institution Building at Washington, D. C. Professor Burton E. Livingston, of the Laboratory of Plant Physiology of the Johns Hopkins University, is permanent secretary of the association, and is assisted by Mr. Sam Woodley, mana-

DR. A. J. GOLDFORB
PROFESSOR OF BIOLOGY, COLLEGE OF THE CITY OF NEW YORK; CHAIRMAN OF THE SECTION OF MEDICAL SCIENCES.

DR. FAY-COOPER COLE
PROFESSOR OF ANTHROPOLOGY, UNIVERSITY OF CHICAGO; CHAIRMAN OF THE SECTION OF ANTHROPOLOGY.

ger of the Washington office. Other officers are:

President, Henry Fairfield Osborn; American Museum of Natural History, New York; *retiring president,* Arthur A. Noyes; California Institute of Technology, Pasadena, Calif.; *general secretary,* W. J. Humphreys; Weather Bureau, Washington, D. C.; *treasurer,*

UNITED ENGINEERING SOCIETIES BUILDING

John L. Wirt; Carnegie Institution of Washington, Washington, D. C.; *the vice presidents,* the chairmen of the sections.

The association is composed of sections in mathematics, physics, chemistry, astronomy, geology and geography, zoological sciences, biological sciences, anthropology, psychology, social and economic sciences, historical and philological sciences, engineering, medical sciences,

THE BELL TELEPHONE LABORATORIES

agriculture and education. A number of national scientific societies are associated with each section and usually meet at the same time, although their programs are sometimes separate. Each

MUSEUMS OF THE PEACEFUL ARTS

ONE OF THE HUNDRED OR MORE VISITOR-OPERATED EXHIBITS AT THE MUSEUM AT 24 WEST 40TH STREET. THE PHOTOGRAPH ABOVE SHOWS A VISITOR MEASURING IN 1/100,000THS OF AN INCH, BY MEANS OF LIGHT WAVES, THE DEFLECTION OF A STEEL RAIL CAUSED BY THE SLIGHT PRESSURE OF A FINGER ON THE TOP OF THE RAIL.

section has its own officers, the chairman being a member of the association council. These officers arrange the section programs for the annual meetings of the association.

The annual meetings take place during Christmas week. Once in four years they are held in Washington, Chicago or New York. Other cities are visited in intervening years. In addition to the Christmas meetings and occasional other meetings the association actively supports research workers, endeavors to encourage friendly cooperation among scientific institutions and individuals and to aid scientific publications.

Membership in the association carries with it annual subscription to either *Science* or THE SCIENTIFIC MONTHLY, in both of which accounts of association activities appear.

This great association of the English-speaking scientists of North America

DR. HOWARD C. WARREN
PROFESSOR OF PSYCHOLOGY, PRINCETON UNIVERSITY; CHAIRMAN OF THE SECTION OF PSYCHOLOGY.

DR. TRUMAN L. KELLEY
PROFESSOR OF EDUCATION AND PSYCHOLOGY, STANFORD UNIVERSITY; CHAIRMAN OF THE SECTION OF EDUCATION.

meets in New York City for the eighty-fifth conference of its history. Five of its past presidents are residents of New York and will attend the sessions. Their photographs accompany this article. They are Edmund B. Wilson, J. McKeen Cattell, Simon Flexner, Michael I. Pupin, John Merle Coulter and Henry Fairfield Osborn.

Although this is the eighty-fifth meeting of its corporate career the American Association really dates back to 1839 and the formation of the Association of American Geologists by members of the New York Board of Geologists. Dr. Ebenezer Emmons, W. W. Mather, Edward Hitchcock and Lardner Vanuxem were moving spirits in this organization, which took formal being at a meeting in the Hall of the Franklin Institute of Philadelphia on April 2, 1840. There were eighteen members of the association, five of them from the New York

Survey. The Rev. Edward Hitchcock was chairman.

Three years later the geologists' association widened its scope and became the Association of American Geologists and Naturalists. Accounts of the meetings of this body were published in the *American Journal of Science*. There were seventy-seven members who attended the meetings or presented communications. Sixteen of these men were professors and four clergymen. This was 6 per cent. less theology than in the British Association, which had been organized in 1831 with 25 per cent. of its members clerics, including the eminent geologists Buckland and Sedgwick.

In 1847 it was decided to further extend the scope of the association and on September 20, 1848, again at Philadelphia, the American Association for the Advancement of Science was established. William C. Redfield, the first president, was a meteorologist and physicist. He was a prime mover in the formation of the larger association, although the actual business of formulating rules was done by H. D. Rogers, Benjamin Peirce and Louis Agassiz. Largely through Agassiz's influence the association was modeled after the British Association for the Advancement of Science, under which he had worked. Agassiz was also responsible for the object of interesting the general public in scientific accomplishment, an aim of his life which was realized by the establishment of many of our national museums, notably the Cambridge Museum of Comparative Anatomy and the American Museum of Natural History and in the science departments of numerous American universities.

The year 1848 knew political unrest and the opening up of a new era in the history of the United States. Revolutionary struggles racked Europe, but in America the Mexican War closed and the treaty signed in February brought a vast new territory under our flag. Covered wagons started westward. Gold was discovered in California. Exploring expeditions added zest to the geological study of the day. The postal connection between the United States and Great Britain stimulated international contacts, while the completion of the High Bridge Aqueduct in New York City was an engineering event. Spiritualism was given its first public demonstration and Mormons were persecuted at Nauvoo, Illinois. Also, in July, the great woman's suffrage movement held its first woman's rights convention. It was a year of beginnings and among them the American Association, whose eighty-five years of life have brought a growth hardly dreamed of in 1848.

—From the American Museum of Natural History

THE AMERICAN MUSEUM OF NATURAL HISTORY

THE SCATTERING OF ELECTRONS BY CRYSTALS[1]

By Dr. C. J. DAVISSON

BELL TELEPHONE LABORATORIES, NEW YORK

THE special interest which attaches to the experiments with electrons made by Dr. Germer and me is due to their lending a certain quite definite support to the hypothesis from which has sprung the wave theory of mechanics—the hypothesis put forward by de Broglie in 1924 that just as it is convenient in certain circumstances to regard X-rays as particles rather than as waves, so it will be found convenient in certain circumstances to regard electrons as waves rather than as particles.

I should like to be able to state that Dr. Germer and I were greatly impressed by the reasonableness of this hypothesis, and that we set about at once to devise an experiment in which the wave nature of electrons would be revealed by the phenomenon of interference. The fact is, however, that the considerations which led us to investigate the scattering of electrons by a crystal of nickel were of quite a different sort. And it may be of some interest if, in describing the experiments, I tell what these considerations were.

Our interest in the general subject of electron scattering dates from a simple but significant observation which we chanced to make in the Bell Telephone Laboratories in the year 1919. What we observed was that when a beam of electrons is directed against a metal target some of the incident particles are scattered without appreciable loss of energy. Electrons having the same speed as those in the incident beam stream out in all directions.

This was in 1919, and at that time one was restricted in the views one might hold in regard to a phenomenon of this kind. Scattering without loss of energy might result from a collision of the electron with a single atom, or from collisions with two or more atoms—and these exhausted the possible explanations. We convinced ourselves that single collisions were much the more likely, and set about investigating the way in which these full-speed electrons are distributed in direction. We pictured the electrons being swung around in the strong field within the atom, and hoped to find out from their distribution-in-direction something about this atomic field. What we were attempting, in short, were atomic explorations similar to those of Sir Ernest Rutherford and his collaborators, but explorations in which the probe should be an electron rather than an alpha particle.

Our earliest observations were made upon electrons scattered by targets of polycrystalline nickel. In 1925 Dr. Germer and I were continuing these observations when we discovered, much to our surprise, that the way in which the full-speed scattered electrons are distributed in direction depends upon the size of the crystals in the target. If the crystals are small so that the number under bombardment is great the distribution is simple and the same for different targets—but if the crystals are large so that scattering occurs from a few only, the distribution is irregular; there are great concentrations of scattering in some

[1] Based on an address given by invitation before Section A, British Association for the Advancement of Science, Glasgow, September, 1928.

directions, and only comparatively weak scattering in others.

Curves illustrating this difference between the scattering by small and large crystals—or rather, by many and few crystals—are shown in Fig. 1. But first barding potential 75 volts. The one on the left is typical of the scattering by a target comprising many small crystals, while that on the right was obtained when the number of crystals under bombardment was only ten or a dozen.

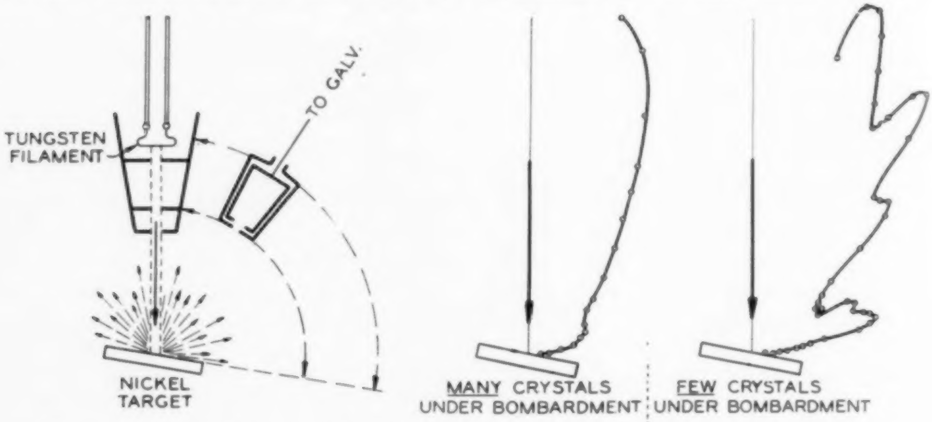


FIG. 1. ELECTRON SCATTERING CURVES OBTAINED FROM BLOCKS OF NICKEL CONTAINING RESPECTIVELY MANY CRYSTALS AND FEW CRYSTALS.

I must explain how these curves were obtained. The method of observation will be made clear by the diagram on the left. Electrons emitted by a tungsten filament are accelerated and some of these, after passing through a series of apertures, emerge in a narrow beam or pencil from the "electron gun." This beam is directed against the target, from which electrons of various speeds stream out in all directions. The intensity of scattering in different directions is then determined by measuring the current received by the inner box of the collector as it is moved from one position to another. We are interested primarily in only those electrons which leave the target with the same speed, or nearly the same, as those in the incident beam. Our observations are restricted to this class by maintaining a retarding potential of appropriate magnitude between the parts of the collector. The distribution curves shown in Fig. 1 are both for nickel, and are both for bombarding potential 75 volts.

It was this result rather than de Broglie's hypothesis which led us to investigate the scattering by a single crystal. We were convinced that this irregular pattern could result only from a marked dependence of the intensity of scattering upon crystal direction, and we set about to find what this dependence might be. And now I must go somewhat into detail in describing the experimental conditions which we tried to realize in these new experiments, and to do this I shall make use of two diagrams.

Nickel forms crystals of the face-centered cubic type, the edge of the unit cube being 3.51 A in length. The block of 27 unit cubes shown on the left in Fig. 2 will serve as a symbol to represent the crystal which we eventually produced and with which we began our investigation. First we cut through this structure at right angles to one of the cube diagonals, exposing the triangular face shown in the central figure. We

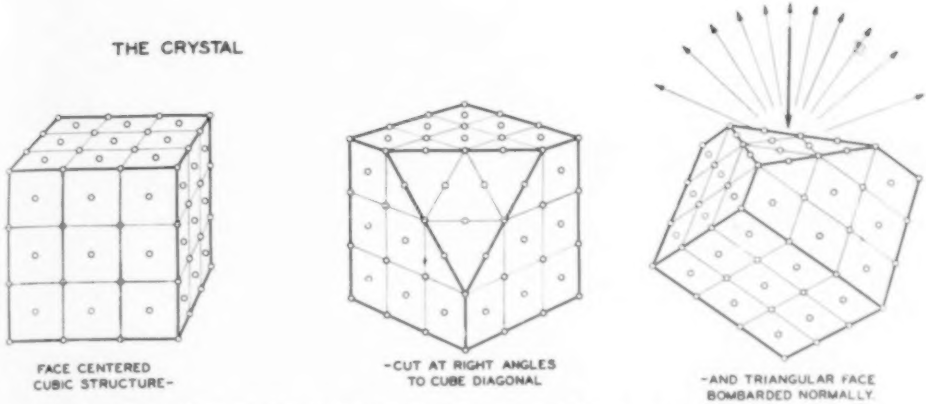


FIG. 2. SCHEMATIC REPRESENTATIONS OF THE FACE-CENTERED CUBIC CRYSTAL OF NICKEL.

then arranged to bombard this newly formed surface at normal incidence as illustrated on the right.

We wished, of course, to measure the intensity of scattering not only in a single plane as in our previous experiments, but in various planes or azimuths about the incident beam. To accomplish this we adopted the arrangement shown in Fig. 3. The collector could be rotated about the bombarded area in a single plane as before, but in addition the crystal itself could be rotated about the axis of the incident beam, so that any azimuth of the crystal could be brought into the plane of the collector. It is clear, of course, that a certain restriction is imposed by the symmetry of the crystal upon the type of scattering pattern that can be observed with this arrangement; the threefold symmetry of the crystal is necessarily reflected in a threefold symmetry of the pattern. The principal azimuths of the crystal are the set of three which include the apexes of the triangle, the set of three which include the mid-points of the sides of the triangle, and the set of six lying parallel to these sides. These we designate the A-, B- and C-azimuths respectively.

It was in April, 1925, that we set out to produce a nickel crystal of appropriate size for this experiment, and it was May, 1926, before the arrangement illustrated here was completed and we were ready to make observations. In the meantime the suggestion had been made by Elsasser in Germany that evidence of the interference of de Broglie waves would be found in the scattering of electrons by a single crystal. We knew of this suggestion, but did not think highly of it. We could see no evidence of a wave phenomenon in any of our previous results, and we did not expect to find any in these new experiments. Our expectation was that we would find beams of electrons streaming out along what might be termed the transparent directions of the crystal structure.

The irregularities we had observed in the scattering pattern of the coarse-grained nickel target were very pronounced when the bombarding potential was 75 volts. For this reason our first observations with the single crystal were made at this voltage. We turned the crystal to bring one of the A-azimuths into the plane of the collector, and determined the form of the distribution curve. We were surprised and disappointed to find that it was indistinguishable from what would have been observed had the target been one of ordinary polycrystalline nickel—a simple curve with never a bump or spur from

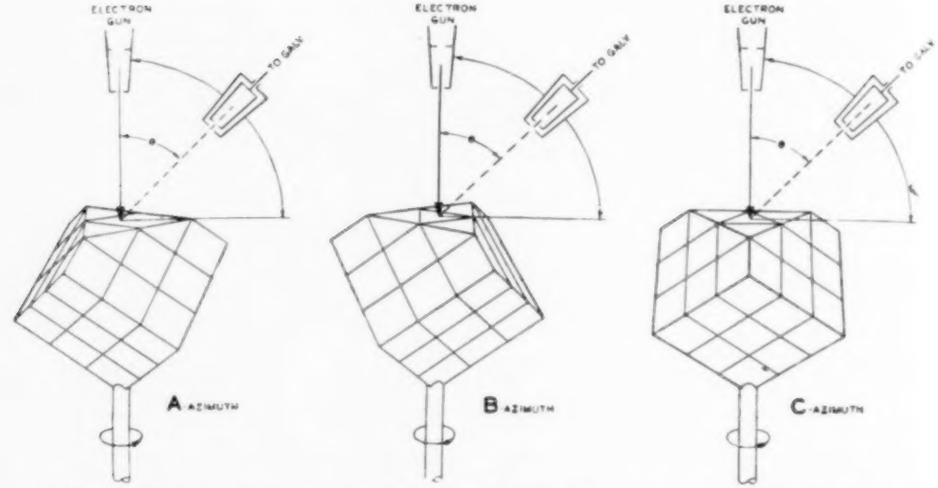


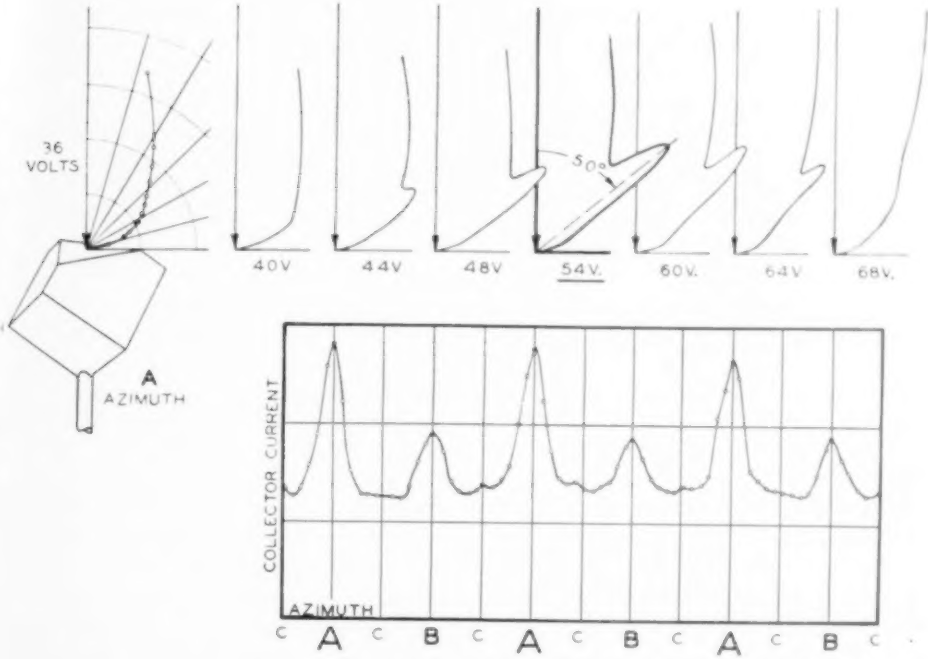
FIG. 3. SCHEMATIC REPRESENTATION OF THE EXPERIMENTAL ARRANGEMENT USED FOR INVESTIGATING ELECTRON SCATTERING FROM A SINGLE CRYSTAL.

one end to the other. The B- and C-azimuths were explored with the same result.

While we were wondering how this could be the tungsten filament which supplied the bombarding electrons burned out, and what with various interruptions and delays it was several months before the damage was repaired and we were able to continue the observations. In the meantime I had had the pleasure and the benefit of attending the Oxford meeting of this association, and of discussing these matters with Dr. Hartree, Professors Born and Franck and one or two others. And when the measurements were resumed a month later we were rather hoping, I think, to find something in the nature of an interference phenomenon. At any rate, we began a systematic study of the distribution curves of each of the principal azimuths, beginning at the lowest bombarding potential at which observations could be made and working upward. And in January, 1927, we came upon the first departure from the simple type of curve. We found that beginning at about 40 volts a slight bump was noticeable in the distribution curve for the A-azimuth, that this bump developed into a strong spur as the voltage was increased, and that after attaining a maximum development at 54 volts, it weakened progressively and disappeared from the curve at about 70 volts.

A family of curves exhibiting this behavior is shown in Fig. 4. These are A-azimuth curves for bombarding potentials 36 to 68 volts. The spur is strongest at 54 volts, and its axis at this voltage lies at colatitude angle $\Theta = 50°$. The curve at the bottom of the figure was obtained by setting the collector in the axis of the spur at maximum development, and then measuring the current to the collector as the crystal was rotated. We find a strong maximum in each of the A-azimuths.

Here at last was our dependence of the intensity of scattering upon crystal direction, and here also was the suggestion of an interference phenomenon, for the shining out of those beams at a particular speed of bombardment is clearly similar to the shining out of a set of Laue beams such as might have been observed had our incident beam been



AZIMUTH CURVE FOR[θ=50°, V=54 VOLTS]

FIG. 4. CURVES SHOWING THE SELECTIVE SCATTERING OF ELECTRONS AT AN ANGLE OF 50° FOR A BOMBARDING POTENTIAL OF 54 VOLTS.

one of monochromatic X-rays of adjustable wave-length. But here the similarity seemed to end, for we found on making the calculations that no one of the important A-azimuth Laue beams lies in the direction $\Theta = 50°$. If the wave-length of an incident beam of X-rays were decreased from some large value, the first set of Laue beams to appear would indeed lie in the A-azimuth—not, however, at $\Theta = 50°$, but at $\Theta = 70°$. And the next set to appear in this azimuth would lie at $\Theta = 44°$.

We were most anxious, of course, to calculate an equivalent wave-length for this electron beam at $\Theta = 50°$ to find if it might agree with the de Broglie wave-length h/mv for electrons of speed corresponding to 54 volts. But the beam does not lie in the direction of regular reflection from any of the important sets of Bragg atom planes of the crystal, and it was impossible, therefore, to follow the usual procedure and to make use of the Bragg formula for this purpose. The Bragg formula is not, however, the only means available for calculating the wave-lengths of Laue beams. It may be shown, for example, that the wave-length of each such beam satisfies the ordinary plane-grating formula of optics with respect to one or another of the plane gratings formed by lines or files of atoms lying in the surface of the crystal. Thus the atoms in the surface of our crystal may be regarded as arranged in lines at right angles to the plane of the A-azimuth. These lines of atoms form a line grating of which the constant is 2.15 A, and the wave-length of every Laue beam appearing in this azimuth satisfies the ordinary plane-grating formula with respect to this grating. The fact that this formula

could be applied in a perfectly definite way to calculate an equivalent wave-length for our beam of electrons, whereas the Bragg formula could not, was not perhaps very good justification for its use, and yet I do not recall that this caused us any great amount of worry. We applied the formula and obtained a wave-length which was, indeed, in very good agreement with the value of h/mv for 54-volt electrons, the values being 1.65 and 1.67 A respectively.

And now I should like to anticipate the conclusion at which we shall shortly arrive—namely, that electrons are indeed scattered as if they were waves—to remark that these waves are appreciably absorbed in traveling only atomic distances in solids, and that, as a consequence, a film of gas on the surface of the crystal acts as an absorbing screen to reduce very materially the intensity of diffraction beams such as shown in Fig. 4. The surface of the crystal was, in fact, heavily coated with gas at the time these first observations were made. The curves shown in Fig. 5 are for this same beam when the crystal is in a gas-free condition—the gas having been removed by heating. The intensity of the beam has been increased by this treatment about fourfold.

We found next a beam in the B-azimuth which is most intense when the bombarding potential is 65 volts, and which lies at $\Theta = 44°$. Again there is no important Laue beam lying in this direction, but again the wave-length of the beam calculated from the plane-grating formula was in good agreement with that calculated from $\lambda = h/mv$—the values being 1.50 and 1.52 A respectively.

The explorations were then extended to 370 volts, and in this range seventeen additional sets of beams upon which measurements could be made were found in the three principal azimuths. The agreement between the wave-length calculated from the grating formula and that given by the de Broglie relation is not so good in all cases as for these first beams, but the disagreement seems to us in no case excessive in view of the difficulty of the measurements. In Fig. 6 we have plotted the results of all the wave-length measurements we have so far made. These include the nineteen measurements just described, and in addition a few others in which the incident beam meets the crystal surface other than normally. What are plotted are observed wave-lengths, those calculated from the grating formula, against theoretical wave-lengths, those calculated from $\lambda = h/mv$. And what we conclude from this diagram is that these quantities are equal within the limits of accuracy of our measurements.

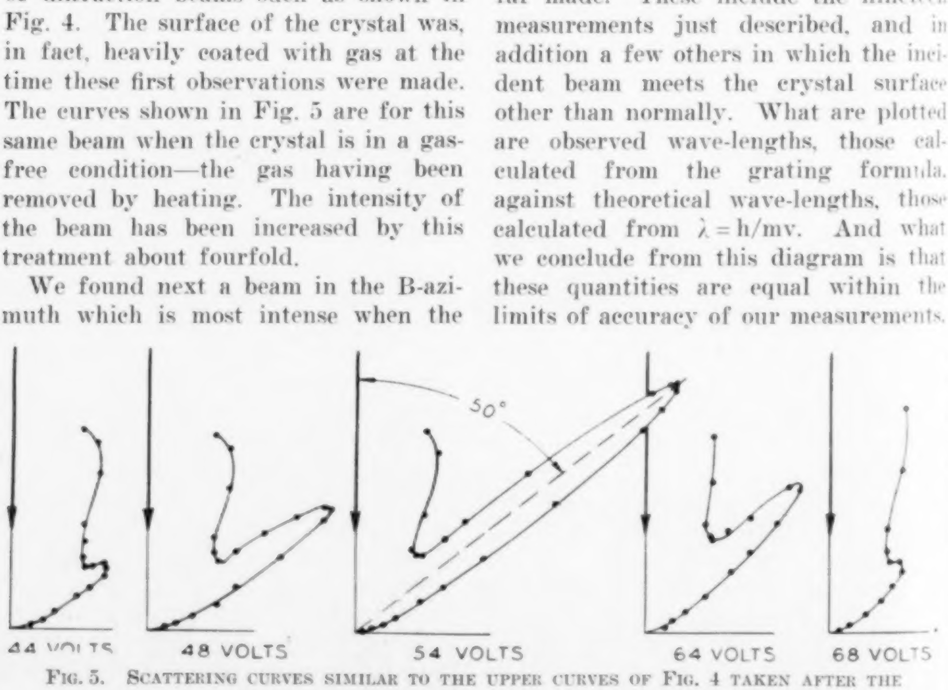


FIG. 5. SCATTERING CURVES SIMILAR TO THE UPPER CURVES OF FIG. 4 TAKEN AFTER THE CRYSTAL SURFACE HAD BEEN FREED FROM ADSORBED GAS BY HEATING.

We have not been concerned in this comparison of wave-lengths with the reason why the directions taken by the electron beams are not the same as those taken by the Laue beams. We have taken the electron beams as we have found them and have calculated their wave-lengths without regard to their law of occurrence. This law is clearly not the same as the law of occurrence of Laue beams, and yet it is evident from an examination of the data that the two laws are in some way related. To illustrate this we display the data in a diagram (Fig. 7) in which we coordinate wave-length and the sine of the colatitude angle Θ. This particular diagram is for the A-azimuth. The crossed circles coordinate the wave-lengths and angles of Laue beams occurring in this azimuth, and the solid dots coordinate the same quantities for the electron beams, the wave-lengths being calculated from the de Broglie formula. The crossed circles representing the Laue beams fall on straight lines through the origin, and these straight lines are the graph of the plane-grating formula for this azimuth, in its various orders. Our first conclusion may be restated by saying that, within the limits of accuracy of our measurements, the solid dots representing the electron beams fall along these same straight lines.

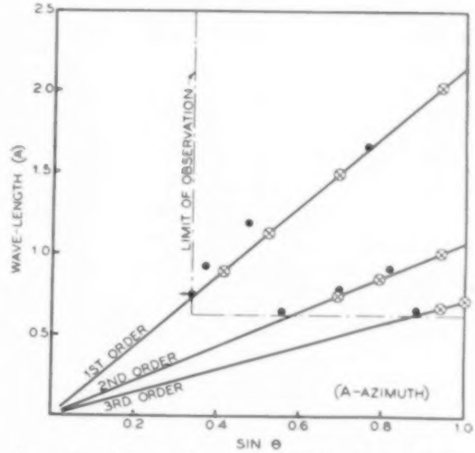


FIG. 7. DIAGRAM CORRELATING THE WAVE-LENGTHS AND ANGLES OF OCCURRENCE OF ELECTRON BEAMS AND OF X-RAY BEAMS IN THE A-AZIMUTH OF THE NICKEL CRYSTAL.

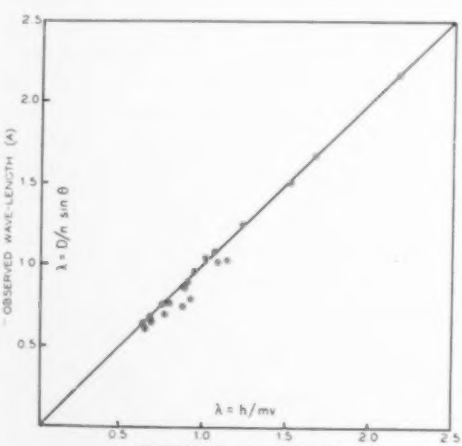


FIG. 6. GRAPHICAL COMPARISON OF ALL EXPERIMENTALLY DETERMINED VALUES OF ELECTRON WAVE-LENGTH WITH THE THEORETICAL VALUES GIVEN BY $\lambda = h/mv$.

What we see represented in Fig. 7 is a certain array of Laue beams, and a certain rather similar array of electron beams. It is not difficult, in fact, to imagine a one to one correspondence between the beams of the two sets. It is as if each electron beam were the companion or analogue of a particular Laue beam, and as if the electron beams were displaced in some systematic way from their Laue beam analogues. In our first report of these results we said that the electron beams occur as the Laue beams would occur if the scale of the crystal were altered by a certain factor in the direction parallel to the incident beam. What we failed to see at the time is that displacements of the type observed—displacements along the plane-grating lines in this figure—would result if there were a refraction of the electrons by the crystal. This suggestion was made by Eckert and also by Bethe. The suggestion is a particularly attractive one as it affords

a justification of the use of the plane-grating formula for calculating wave-lengths.

Our recent efforts have been directed toward finding whether or not this idea that electron waves are refracted in accordance with the same laws as light and X-rays is really tenable. The procedure has been to find whether or not all differences between the occurrences of electron and X-ray beams can be explained by assuming for the crystal an index of refraction which is a function of electron speed or wave-length only. The results so far obtained are not entirely conclusive. There is, however, a fairly strong indication that the question will eventually be answered in the affirmative. I shall have something more to say about this matter of refraction, but for the present I should like to return to a further consideration of the beams.

Having observed the electron analogue of the Laue diffraction beams, it was quite certain that under appropriate conditions we should observe also the analogue of the Bragg reflection beam. There was no possibility of observing this beam with the first arrangement of the apparatus, as the incident beam met the surface normally, and the regularly reflected beam, if it existed, was outside the range of our observations. In a second experimental arrangement with which we are still working, the angle of incidence can be varied from 0° to 90°, and with this we find, as was anticipated, that the incident beam is regularly but selectively reflected; the intensity of the reflected beam is a maximum at certain critical speeds of bombardment, just as the intensity of the Bragg beam is a maximum at certain critical wave-lengths. Curves from which we infer the existence of the regularly reflected beam are shown in Fig. 8.

These are for angles of incidence of 10, 20 and 35 degrees, and for bombarding potentials for which the intensity of the reflected beam is at a maximum. In each of these cases and in every similar case which we have examined the axis of the spur lies accurately in the direction of regular reflection. These observations, unlike the previous ones, were made with no retarding potential between the parts of the collector. Electrons of all speeds were accepted into the inner box, and the reflected beam shows up against this strong background.

The curves in Fig. 8 illustrate the regularity of the reflection. Its selectivity is illustrated by the curve in Fig. 9. What we have plotted here is the intensity of the reflected beam for angle of incidence 10° against the reciprocal of the de Broglie wave-length. The angle of incidence is held constant at 10°, the intensity of the reflected beam is measured for various speeds of bombardment, and these intensities are plotted

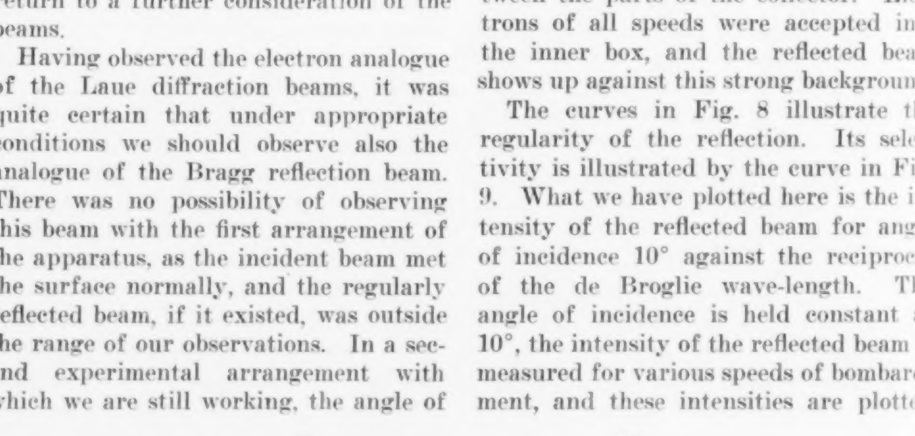


FIG. 8. CURVES SHOWING THE REGULAR REFLECTION OF ELECTRON WAVES FROM A CRYSTAL SURFACE.

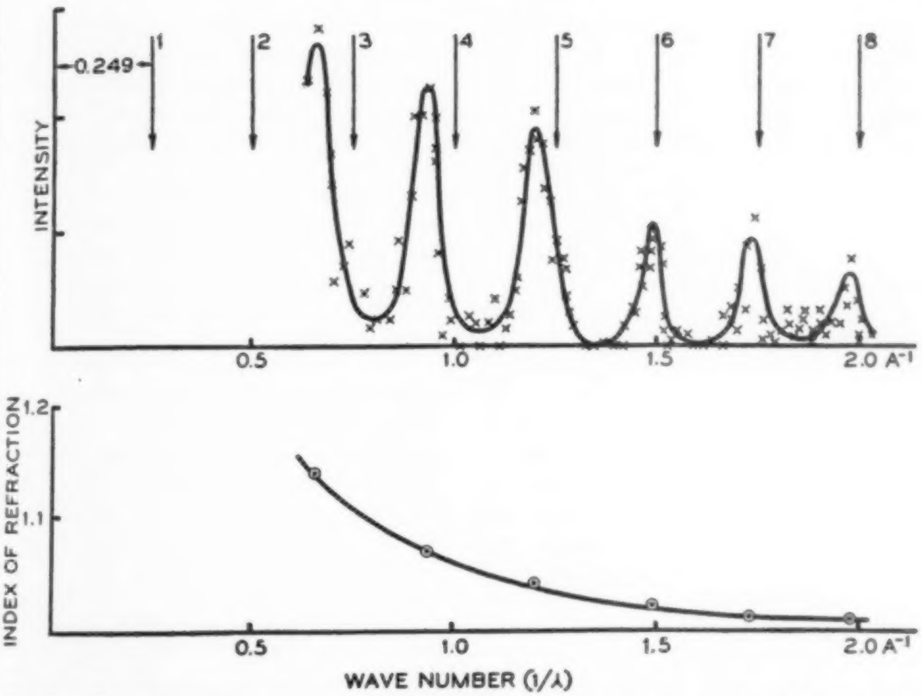


FIG. 9. CURVE SHOWING THE SELECTIVITY OF ELECTRON REFLECTION FOR ANGLE OF INCIDENCE 10°, TOGETHER WITH VALUES OF REFRACTIVE INDEX CALCULATED FROM THIS CURVE.

against the reciprocals of the corresponding wave-length. The equivalent experiment with X-ray could not be made at all conveniently, since with X-rays we do not have available a monochromatic beam of easily adjustable wave-length. It is quite easy, however, to deduce from Bragg's law what would be observed. We find that the corresponding curve for X-rays would be characterized by equally spaced maxima, the distance between successive maxima being 0.249 on our scale of abscissae. The positions or wave-lengths at which these maxima would occur are indicated by the arrows in the figure. If the Bragg law obtained also for de Broglie waves, the maxima in this curve for electrons would occur at these same positions. That they fail to do so is, of course, not surprising. We have seen that the electron diffraction beams fail to conform to the Bragg law, and it would be puzzling, indeed, if this law were found to obtain in the case of the reflection beam. Here again the difference between the electron and X-ray phenomena is such as might result from electron refraction. It is quite easy, in fact, to calculate from the curve in Fig. 9 indices of refraction for electrons of the speeds corresponding to these maxima. The values found are plotted in the lower part of the figure. They decrease regularly from 1.14 to 1.01 as the wave number $1/\lambda$ is increased from 0.6 to 2.0 A^{-1} or as the bombarding potential is increased from 60 to 600 volts.

Now electron refraction is in a way a reasonable and acceptable sort of phenomenon. We know that electrons are accelerated as they pass into a metal, and if we want to regard electrons as particles rather than as waves we may explain the refraction of electrons as

Newton explained the refraction of light on the corpuscular theory. If we prefer waves we think of the change in potential experienced by the electrons on passing into the metal and calculate a change in wave-length either from the de Broglie formula, or by means of the Schroedinger wave equation. Whichever view we take we are led to expect that the index of refraction will be appreciably greater than unity for electrons of low speed, and that it will approach unity according to a certain simple law as the speed is increased. The form of the dispersion curve should, in fact, be much the same as indicated by these results. What we may call the scale factor of the curve is determined by a single parameter—a potential difference characteristic of the metal, which we naturally think to identify with its thermionic work-function. It is somewhat surprising, therefore, that to account for the scale factor of the dispersion curve shown in Fig. 9, we must assume a work-function equivalent to about 18 volts—a quantity much too large to be mistaken for the ordinary thermionic work-function of nickel.

But again the theorist is ready to resolve the riddle. The interesting suggestion has been made by Bethe that the refractive index is determined not by the Richardson work-function, but by the larger absolute work-function which figures in the Fermi-Sommerfeld theory of electrons in metals. Eighteen volts, it appears, is an acceptable value for this latter constant.

And now it is too bad to have to report that the further measurements which we have made of the refractive index confirm the curve shown here only in the region to the right of $1/\lambda = 1\ A^{-1}$. In the region to the left the dispersion is much less simple than was indicated by these first results. The dispersion curve in this region is, in fact, highly complicated, as will be seen from Fig. 10, in which we have plotted all values of refractive index obtained in these measurements. What interpretation is to be placed upon these flourishes we do not know. There is a suggestion

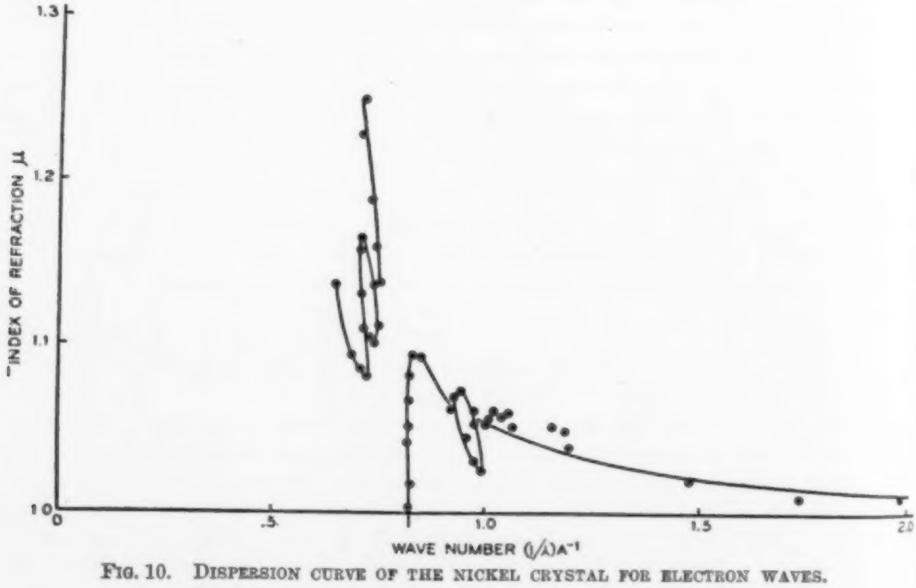


FIG. 10. DISPERSION CURVE OF THE NICKEL CRYSTAL FOR ELECTRON WAVES.

here, of course, of a resonance phenomenon such as that to which we ascribe the anomalous dispersion of light, but oscillators and resonance would appear to have no place in the theory of electron dispersion.

It has been remarked already that for electrons of high speed the index of refraction approaches unity as the speed is increased. At 600 volts the index is about 1.01, and at 1,000 or 2,000 volts it should be equal sensibly to unity. The geometrical differences between electron and X-ray diffraction should, therefore, decrease as the speed of bombardment is increased and should become imperceptible when the bombarding potential is measured in thousands of volts. That this is true is clearly shown by the beautiful experiments which have been reported by Professor G. P. Thomson and his collaborators.

GEOLOGY, ITS STUDY AND RELATIONSHIPS

By Professor BRADFORD WILLARD

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GEOLOGY is earth science. It is less a true science than it is a league of closely related sciences. To the student of geology a broad field of investigation is open. He must master his own chosen realm of study, and must supplement this with many courses in other fields of learning. With the accompanying relationship diagram before us, let us consider what sort of curriculum must be followed if one would become a specialist in geological work.

The beginner usually first makes contact with geology through a course in physiography or physical geography, followed by one in historical geology, that is, earth history. From these as a foundation, his undergraduate studies lead him into fields devoted to the various divisions of geology. Often he is undecided what in earth science appeals most to him, and it is just this "browsing around" during undergraduate days which gives him the opportunity to select a branch for further, concentrated specialization. Following his introductory year, he usually attends a course in mineralogy and crystallography with some petrography and petrology and leading to more advanced courses in petrography or optical mineralogy. These are logical preludes to studies in metallic economic geology, since it is here that training in mineralogy is most applicable. As he continues, he may register in courses in stratigraphy and sedimentation, structural and dynamical geology, prospect-

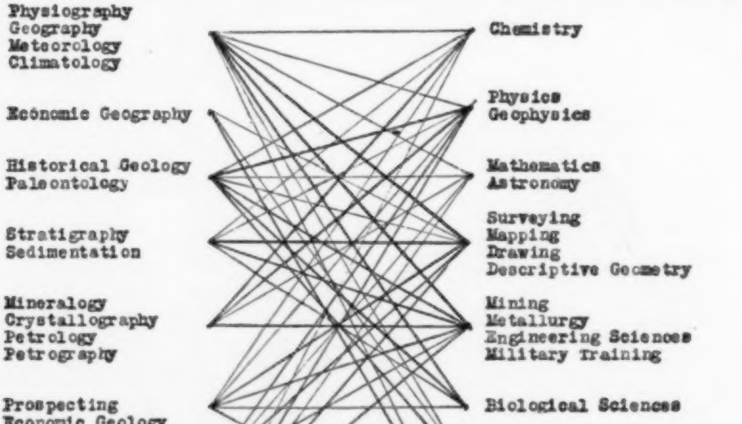


TABLE OF GEOGRAPHICAL RELATIONSHIPS.

ing, paleontology, and so forth; or, if he has a leaning toward a business career, he may specialize in economic geography. By his senior year he is fitted to undertake a simple field problem such as mapping the geology of a small area, solving a problem in physiography or interpreting some bit of rock structure. But if he is to step into remunerative geological work his training should not stop with only undergraduate studies.

Specialized graduate work is now held a necessary preparation for the student of earth science. Seldom to-day can a man with only a bachelor's degree and a few courses in geology to his credit secure geological work, much less aspire to teach in the field. Graduate studies usually lead into some form of specialization. He may make his major mineralogy and petrography. On the other hand, with these subjects as a minor study, he perhaps devotes himself to mastering the principles of economic geology. Advanced physiography and economic geography in conjunction with courses in economics may occupy his graduate years, constituting a "split major." Again, stratigraphy and paleontology offer inducements to the student interested in evolution and earth history and having a liking for biological subjects. Still others find it their preference to carry on, during graduate years, a general advanced course in several branches of geology, this chiefly in the cases of those preparing to teach. In whatever field the graduate may continue, research problems must be undertaken, perhaps as theses, best developed in actual field work in summer schools of geology or, preferably, in regular, off-campus, geological employment.

On completion of graduate work, for what is the newly fledged, would-be geologist suited? His training may be of the best, but he still lacks that most essential of all qualifications of a geologist (omitting the physical)—actual experience in unsupervised application of his understanding of earth phenomena. How may he secure this training? First, there is geological survey work. Such surveys are maintained by the federal and a number of state governments. A more excellent field of training can hardly be found. There is a steady demand for geologists in private enterprises, mining, metallurgy, engineering all requiring their assistance. But such applied geology is not the limit of possibilities. We may also designate certain types of more theoretical work, teaching and research positions and museum employment. Rare indeed is the college or university to-day without at least one geologist on its staff of instruction. Many employ several, usually representing the divisions of physiography, general geology and mineralogy; and the larger institutions retain men in less common branches.

But the scholastic training of a geologist is not confined to the subjects taught by his own department. It would be impossible for him to master these without supplemental work. Can the mineralogist work without chemistry; the paleontologist without biology? Consider briefly what such extra-geological training must be.

Assume that a student has elected to specialize in economic geology. His field lies chiefly along lines associated with mining, and metallurgy, surveying and mapping, engineering methods, plus economics and business administration. He should attend at least elementary courses in as many of these subjects as time will permit him. As a geologist his training must be most complete in mineralogy and petrography, since upon these depends his ability to recognize ores, understand their occurrence and interpret their origin. A study of mineralogy implies a knowledge of con-

siderable chemistry, an ability to "run analyses" of rocks and ores and understand the chemical make-up of minerals. Physics is useful in the application of the laws of optics and light to the operation of the petrographic microscope. A student of economic geology should understand prospecting, for it is the geologist who finds the ores which the mining engineer extracts and the metallurgist refines. Structural and dynamical geology must be added. Through the former the geologist understands the "lay" of the rocks underground. Deep-buried structures are more readily understood if the student be trained in descriptive geometry. Dynamical geology teaches him physical and chemical changes which have metamorphosed the rocks, often resulting in the formation of ore bodies. Here again a knowledge of physics is needed in appreciating the mechanical forces involved in metamorphism. Such knowledge is but a step removed from geophysics with mathematics an assumed adjunct. A large proportion of the economic geology of to-day is concerned with non-metallic products, such as petroleum and natural gas, coal and cement. The search for these, particularly the petroleum and natural gas, demands an understanding of stratigraphy and sedimentation in order that the worker may interpret the origin of bedded deposits of rocks and the occurrence of their included economic products. In oil work, incidentally, ability to survey and map is even more helpful than in most geological field work. It is an essential part of the training of a geologist whatever his specialty. Paleontology, chiefly micropaleontology, becomes of prime importance in studying the minute organisms whose fossil remains are to-day so largely used as guides to oil-bearing strata.

But suppose a student chooses paleontology as his field of work. Paleontology takes into consideration the biology of extinct plants and animals, their evolution and their relation to living forms. It teaches of the former distribution of organisms and allows glimpses of ancient climatic conditions. The student of paleontology should include among his courses zoology, botany, comparative anatomy, embryology, evolution and anthropology; a smattering of bacteriology and archeology will do no harm. The paleontologist is usually most concerned with earth history, organic evolution and problems of stratigraphy, the last since it is from the stratified rocks that fossils are collected; while, conversely, the kinds of organic remains present are usually a clue to the conditions under which the enclosing strata originated. For such applications he must know some chemistry and physics. Geophysics enters his line of vision since it is tied up with the great earth movements of the past and the development of earth structures and features through the ages. The paleontologist as a student of earth history meets the astronomer half-way in that their respective investigations dovetail one another in accounting for the origin of the earth.

These are but two examples of the type of geological and extra-geological studies a student in the field of earth science should pursue. It might be emphasized that no matter in what division he may concentrate, there are at least three essential non-scientific studies to be added. First, he should be able to make a respectable, if not artistic freehand sketch and know enough mechanical drawing to teach him familiarity with the drawing board and instruments. Second, a reading knowledge of foreign languages is not to be omitted from his training. Witness the established requirements of students who are candidates for the doctor's degree in any science. They must have at least a good

grounding in French and German. Spanish and Italian are no superficial additions to the list. Finally, and perhaps most essential of all three and yet probably the most neglected, is the ability to prepare a written report in clear, concise, scientific English.

So much for the training received by a geologist in his own and supplementary fields of study. What of the converse? Can a knowledge of geology be of value to those who chose other fields of investigation, scientific or otherwise? Consider a few examples.

What of the chemist? Is it of any value to him to know the origin, occurrence and economic value of many naturally occurring substances with which he often works? Here opens the broad vista of geochemistry. The geophysicist must, for his highly specialized investigations, be trained in geology and physics. The economist better understands the distribution of raw products through a course in ecomonic geography. Meteorology and climatology explain how weather and climate influence business conditions. Nor can he afford to ignore the world's leading regions of great mineral wealth, made known through economic geology. Turn to the engineering profession. Of mining and metallurgy enough has already been said. What civil engineer dares be oblivious to bed-rock conditions when selecting a cite for a huge dam, in excavating for a foundation, driving a tunnel or sinking a shaft? His training in the strength of materials is certainly not hampered if he knows the mineral composition and weather-resisting qualities of common building stones. The military engineer must apply geology. Its value was emphasized only too clearly in France. An army needs potable water. Topography is one of the great considerations in a military operation. Where, too, is the unit which, under fire or otherwise, can "dig in" into solid rock? A knowledge of subsurface conditions is indispensable to mining and sapping. Furthermore, can the surveyor do better than understand the origin and character of the rocks beneath and the physiographic history of the terraine which he maps? Then there is the historian. Here is one who studies the *few score* centuries of human development. The historical geologist goes back *millions* of centuries. Wells's treatment in "The Outline of History" is an example which may be taken seriously by the all too superficial historian. Let him learn of the prehistoric development of man as a prelude to understanding the historic. In like manner, historical geology forms an excellent supplementary course for one working in social and political science; and through physiography he interests himself in the environment and background of man's development and behavior. Finally, what of the biologist? Let him keep in mind both the axiom, "Know well the present e'er crossing the threshold of the past," and its equally true converse. The zoologist and botanist draw "trees" of evolution, yet see only the tips of the twigs. Train them in paleontology, and figuratively and literally they will dig down to the roots, first exposing the twigs, then the small branches, next the larger limbs and finally the trunk itself. Paleontology is "the documentary evidence of evolution." Teach the student of biology the lore of the fossils, and his comparative anatomy, embryology and above all organic evolution will bear fruit a hundredfold more bountifully.

Why study geology? With the depletion of our larger deposits of mineral wealth, it is to the geologist that the world must turn to discover lesser but increasingly valuable sources of world supply of those commodities without

which our civilization can not hope to survive. Probably the geologist more than any other scientist secures the widest outlook on nature through studies in many fields. A specialist in a branch of earth science, he is also something of a chemist, physicist, economist, biologist and engineer—in short is trained in general science. His work takes him to all sorts of out-of-the-way corners of the earth. He visits distant lands, sees unusual sights and mingles with strange peoples. His work brings him into contact with men busied with other sciences. Conversely, specialists in other sciences, through a little geology, broaden their appreciation of their own fields. Through geology comes a linking together of many subjects, a meeting of trained minds on a common ground. Geology becomes a clearing house for the exchange of ideas and scientific thought leading toward the solution of problems of mutual interest. Furthermore, its study helps eliminate some of those errors in any field all too often committed through ignorance of topics of common knowledge in another.

As astronomy teaches of vast distances, so geology tells of inconceivable lapses of time. More than any other scientist, the student of the composition and behavior of our earth appreciates the work of nature in forming and developing that world. The paleontologist, trained in biology as well as geology and with a deep insight into organic evolution, sees in the stream of life man's "long-continued, slow progress." Lyell, shortly after 1859, began to add geological facts to the evidence gathered in support of organic evolution. Since then geology has taken a leading part in proving and explaining the story of the development of living forms. If these seventy-odd years have produced such results as now we see, what may we expect from the future study of rocks? With these possibilities of coordination of different sciences, cooperation of scientists in related fields, discovery of economic products in mineral wealth, interpretation of the past and above all the evolution plus a hint of the future of the race, need the study of geology lack recruits to its ranks?

ANTIVIRUS VACCINES IN SURGERY

By Dr. STÉPHANE EPSTEIN[1]

It is generally agreed that surgery has made enormous progress during the last fifty years. Operatory technique has itself, of course, made vast strides, and certain adjuncts, such as adrenalin, allow a surgeon to operate with a precision and a rapidity that were formerly unknown. New instruments and the extended use of electricity beyond mere motive power have indicated a new path for surgery. But the chief characteristic of modern surgery as compared with that of the first two quarters of the last century is the marked diminution in deaths resulting from operations. When one reads of the manner in which patients formerly were treated after an operation one asks oneself how a single one could possibly have escaped infection. Hospital rot was worse than any wound and an operation was usually equivalent to a death sentence. Contamination was conveyed by instruments, by the hands of the surgeon or his assistants, by dressings, by the general surroundings

[1] Translated from the French by R. Vivé Bazely.

and lastly by the curative methods themselves. It is not so long ago that cobwebs were applied to cuts and urine to abscesses.

The speeches and pamphlets in commemoration of Lord Lister's centenary give a terrible picture of septicemia following on operations. The average mortality was 40 to 50 per cent., and surgeons only operated when no other issue was possible, and in the case of abscesses waited for them to burst rather than use the lancet. Lister changed all that, and his methods may be regarded as the first stage in the struggle against infection. Sir St. Clair Thompson has rightly remarked that the Lister process has saved more lives than the great military heroes of all ages have managed to destroy.

From the moment when everything that touches a wound was disinfected and the deadly germs destroyed, postoperatory mortality fell to 3 per cent. and a rapid cure was assured.

It was, however, observed that antiseptics applied to wounds killed not only pathogenic agents but even the living cells, with the result that scars were ugly and irregular. An effort, therefore, was made to modify the system without abandoning the principles upon which antisepsis is based. It was argued that, if, instead of destroying the germs, they could be prevented from entering the wound during an operation, nature would do the rest. Sterilization replaced disinfection and heat antiseptics. If operating theater, instruments, hands, dressings, the operating field itself were all sterilized, the bacilli that might be in the wound would lack a favorable ground and a cure would be brought about spontaneously.

Here is then the second stage. The aseptic method has replaced the antiseptic and is supreme in all forms of infection.

Both methods arise out of Pasteur's discoveries which made Lister's possible; without the discovery of the principles of fermentation, sterilization would have remained in the fourth dimension.

But the process of healing was still obscure, and, thanks to Metchnikoff's discovery of the rôle played by phagocytes in the struggle against deadly germs, the necessity of two methods in avoiding infection was perceived—direct destruction of micro-organisms causing necrosis of the living tissues and isolation of the parts liable to infection in order to allow the phagocytes usefully to perform their task. The aseptic method only answers these requirements partially: specific dressings seem to be the next stage after antiseptics and aseptics in the struggle against infection.

In the majority of infected wounds and even in a large number of diseases, we find that two microbes predominate, streptococci and staphylococci.

At first sight both appear peaceable, resembling little regularly formed motionless heaps which take the shape of clusters or chains and are easily colored. But under this benign appearance they are disconcertingly active. The diseases which they occasion or in which they play the leading part are without number. They are to be found in boils, whitlows, otitis, acne, osteomyelitis (inflammation of the bone and bone marrow), in the skin complaints of infants (pyodermitis), inflammations of the eyelid (blepharitis), phlegmons, conjunctivitis, mastitis, purulent pleurisy, puerperal fevers, etc., etc., and in most wounds and infected burns. One can, in fact, speak of two categories of disease, streptococcic and staphylococcic.

Having ascertained the determining rôle of streptococci and staphylococci in septicemia we had to find out whether there was a means of combating these two pathogenic agents in a specific man-

ner. We thought instinctively of serotherapy and curative vaccination, but immediately a serious obstacle arose; in the case of laboratory animals hypodermic or intraperitoneal injections were found inoperative and it was difficult to think of vaccination when experimental infection was impossible. Nevertheless, human beings derived benefit occasionally from anti-streptococcic and anti-staphylococcic immunization. The results were meager, varying and often deficient; still there were results.

Dr. Besredka, to whom we owe so many magnificent discoveries, studied systematically the problem of staphylococci and streptococci. In examining the mechanism of infection and immunity he noticed that in certain microbial affections the entire organism participates in the defense of the integrity of our "self"; in others immunity is a local phenomenon, that is to say that certain tissues have a special predilection for certain microbes, and if there is no contact between the elective tissue and the microbe, the latter can neither multiply nor elaborate its toxins.

Dr. Besredka asked himself at this juncture whether there was not a relationship between streptococci, staphylococci and bacteridia, that is to say that an important rôle must be assigned to the epidermis in the mechanism of infection, and at first sight this seemed little likely.

There is no organ or tissue which does not offer a wide hospitality to streptococci and staphylococci. Lungs, pleura, joints, kidneys and the bone marrow are amply supplied with them in the event of numerous ailments. But even in a state of perfect health we harbor quantities on the surface of the skin, around the hair and in the ocular, nasal, tonsillar and buccal mucosities. They live on us and with us as inoffensive and peaceable parasites. But their appearance is deceptive; they are on the watch for the slightest infraction, the smallest break of continuity, the most insignificant entry through our protecting teguments of skin and mucosae. A slight traumatism, an intercurrent infection, an inferior state of defense, and the streptococci and staphylococci rush in by the breach, causing carbuncles and anthrax which degenerate into lymphangitis, adenitis and phlegmons, and may even be the cause of osteomyelitis, endocarditis, purulent pleurisy. Carried through the lymphatic ducts they make an onslaught on the phagocytes. If they are overcome and digested, a mild and temporary affection ensues. But if the streptococci and staphylococci gain the victory, they rapidly attack the general system, penetrating the organs and provoking the above-mentioned diseases. Once established, these undesirable guests are dislodged with difficulty. Sometimes they remain dormant and there is nothing to indicate their presence. But their slumber is light and the slightest change in the general state of health is sufficient to arouse their activities.

From the foregoing it is seen that the skin is the tissue affected by streptococci and staphylococci, and that it is a question of rendering them innocuous in their very abode and even of pursuing them along the lymphatic ducts.

The Pasteur school quite naturally looked primarily to serotherapy and vaccinotherapy in introducing into the affected organism either a serum containing elements capable of destroying the pathogenic agents or a vaccine which would allow the cells to defend themselves against the microbial invasion. But the theory of local immunity did not then exist. In consequence serums and vaccines were simply injected according to the habitual method. The results of serotherapy as practiced on laboratory animals were plainly negative.

It was suggested as an explanation that rabbits are incapable of sufficient resistance. This, however, could not be said of human beings, who notwithstanding did not derive any more benefit from anti-staphylococcic and anti-streptococcic serotherapy; after the introduction of the serum into a blood channel, there was not the smallest trace of "antibody." In conformity with the doctrine of Almroth Wright (one of Pasteur's most remarkable pupils, who believed that the intramuscular channel was superior to the subcutaneous and the intravenous to the intramuscular), serums were abandoned and anti-streptococcic and anti-staphylococcic vaccines were injected into the veins. The result once more was negative.

What was the explanation, however, of the fact that the injection when made in the muscles produced a slight effect, was more pronounced when subcutaneous and only attained its full form when it did not penetrate the epidermis?

Contrary to Wright's theory, the more one kept to the surface the greater the effect of the vaccine, and the deeper one went, the less it became, until the diminishing point was reached when the injection was made in the vein.

If one admits, however, that the epidermis is the organ of predilection of streptococci and staphylococci, one finds an explanation for the above-mentioned phenomena, and one understands at the same time that the reason why subcutaneous punctures failed to produce any effect was that it is almost impossible not to penetrate the skin, and because the puncture produced a channel forming a connection between the epidermis and the spot where the syringe had deposited the vaccine. By making the tiniest punctures, almost a scarification such as is practiced in anti-smallpox vaccination, one gives the vaccine its maximum efficacy. A rabbit treated in this manner was able twenty-four hours later to support with impunity an injection of living microbes, whereas others, not vaccinated or vaccinated with intramuscular or intravenous injections, sickened and died if the dose was sufficiently strong. In an animal thus vaccinated and refractory to streptococcic or staphylococcic infection no "antibody" was observed.

This strange phenomenon led on inevitably to the question whether in the case in point it is really the microbial body that vaccinates or something else of which it is simply the vehicle. The problem became still more disquieting when it was seen that there is no need to inject the vaccine; a simple bandage applied to the stomach after depilation or shaving was sufficient to immunize the animal.

With this idea in view a new experiment was attempted. A rabbit was vaccinated without the help of any microbial bodies by the simple application of their soluble products, in other words, juice. When we prepare an apple jelly, we reject skin, pulp, pips, in fact, everything that is not soluble. We proceed in exactly the same way with our streptococci and staphylococci. We allow our culture to stand for eight to ten days in order to disgorge the microbes, after which we strain it through a filter which retains the microbial corpses, and lastly we heat the juice, or scientifically speaking the filtrate, during half an hour at 100° C. We obtain in this manner a clear yellowish liquid, absolutely atoxic and possessing remarkable vaccinatory qualities. And yet the filtrate we have obtained does not differ outwardly from any other cultural broth. In fact, if we were to place in our filtrate the bacilli of typhoid, cholera, dysentery, ague or any other cultivable microbe, they would flourish extremely well. The contrary would be the case if we introduced

streptococci or staphylococci. In an environment from which nevertheless they issued, these germs remained sterile. Just as the minotaur devoured its own children, so this culture nourishes all but its own progeny. A bandage soaked in a streptococci or staphylococci filtrate and placed on the freshly shaved stomach of a rabbit renders it at the end of twenty-four hours refractory to all streptococci or staphylococci. In order to explain the properties of this filtrate one must suppose that together with the virulent substance fixed solidly on the microbial body, there is another substance, an antivirus, which becomes detached from the streptococcus if one allows it to mature. But whereas the virus is destroyed by heat, the antivirus is "thermostable," resisting a temperature not exceeding 100° C. The process is thus perfectly clear. By allowing the cultures to mature we detach all the soluble products which mingle with the environment; by filtration we eliminate the insoluble elements and finally by the application of heat we destroy the virulent elements, leaving a substance of antivirus. And as we have seen that the liquid thus obtained prevents the development of the microbe of which it is the issue, its action appears entirely logical. Appiied to an infected area, the antivirus isolates the focus, as in a fire, with an impenetrable rampart; the surroundings are effectively protected and the firemen or phagocytes, arch enemies of microbes, easily overcome the bacilli thus deprived of all nourishment and means of development. It is important to see that the bandages extend beyond the infected area. If in the case of a rabbit we restrict the application to a certain spot we vaccinate that and nothing more. On the other hand, by enveloping it in bandages soaked in antivirus we attain the lymphatic ducts and the entire body is protected. We see, therefore, how a purely local protection can be converted into general immunization. Practical application of this observance has given excellent results in carbuncular troubles which have a tendency to recur in the same place. By covering as large an area as possible with an antivirus dressing we succeed in vaccinating organs or entire regions and in avoiding a relapse over a period of several months. It is of the greatest importance to be perfectly certain of the identity of the microbe before using the antivirus, otherwise the bandage will do as much harm as it should do good. Thus, for example, if we use a staphylococcic instead of a streptococcic antivirus, not only will there be no curative action but on the contrary a development of the pathogenic agent. Instead of isolating the fire, we shall be feeding it; instead of extinguishing the flames with water, we shall be adding oxygen to them.

These laboratory experiments have been confirmed by clinical practice. The rapidity with which infected wounds "clean up," the rapid disappearance of suppuration, the steady fall in temperature and the certainty of a cure are often amazing.

The characteristic of dressings or specific instillations is the speedy disappearance of pain that not even morphia can relieve. We have had under observation an aural carbuncle of normal size which was exceptionally painful: ten minutes after the application of an antivirus the patient only experienced a certain itching and at the end of an hour we were able to examine the ear without causing the slightest discomfort. A complete cure was effected in six days.

On another occasion we examined a carbuncle on the calf of the leg that was

so deep that the practitioner diagnosed it as osteomyelitis.

Forty-eight hours after an application of an antivirus there was no more suppuration, and the wound, now clean and healthy, began to close.

A different case was that of a patient who had suffered for eight years from chronic conjunctivitis; he had seen many ophthalmic surgeons and their prescriptions filled a small volume. The secretions revealed on analysis the presence of staphylococci. We instilled two grams of antivirus into the lacrymal cavity. After five days' treatment the secretions became sterile and a cure followed five days later. We kept the patient under observation during five months without noticing the slightest relapse.

But it is in cases of puerperal affections that these specific dressings have saved hundreds of lives. One knows in these maladies how painful, precarious and wellnigh useless are surgical interventions. The antivirus treatment of puerperal complaints has an enormous advantage in being preventive. In the event of a difficult or even normal confinement being followed by a suspicious rise in temperature a bandage is immediately applied; yards of sterilized gauze, soaked in antivirus prepared from streptococci obtained from the patient, fill up all the infected cavities, and it is extremely rare that on the fourth day the temperature has not fallen to normal.

Dr. Levy-Solal, of the Maternity Hospital of St.-Antoine, has employed this method in current practice; and wherever it has been used in time there has not been a single failure.

Antivirus vaccines are beginning to find their way into surgery.

The sterilization of operating area, instruments and bandages, the most scrupulous washing of hands are often insufficient to prevent the intrusion of germs from a direction far removed from the patient. But if, after sterilization, hands, instruments, bandages, the operating field itself as well as its surroundings are washed or saturated with the antivirus, the undesirable germs become innocuous, and septicemia is avoided, thus insuring a rapid recovery.

In addition to purely local applications the antivirus treatment has been found efficacious in deep-seated streptococcic and staphylococcic affections. Intrapleural and even intravenous injections have given unexpected results in the treatment of pleuritic complaints, endocarditis and pleurisy.

So far antivirus has only been used in streptococcic and staphylococcic affections. Nevertheless, vaccine-cultures are now being prepared from other microbes such as colon bacilli, *B. pyocyaneus,* etc.

Certain German bacteriologists go so far as to attest that immunity from typhoid fever can be secured by simply applying compresses.

But the day that we find the means of procuring the antivirus of all microbes, we shall enter a domain of boundless possibilities.

And the day is not far off—nearer, perhaps, than we think—when we shall be able to filtrate the Koch bacillus, and thereby heal tuberculous sores with the same rapidity and certainty with which we now heal streptococcic and staphylococcic septicemia.

EUROPE AND THE POWER MAP

By Professor W. O. BLANCHARD
UNIVERSITY OF ILLINOIS

Europe, the Industrial Continent

Modern industry originated in Europe and that continent remains to-day the world's greatest workshop. This statement is true whether the ranking be based upon the value of the output or upon the proportion of the working population so employed. Even among individual *nations*, not *continents*, while the value of the output of the manufactures by the United States is larger than that of any other country, there is no part of the world where people are so dependent upon industry for a livelihood as in the countries of northwestern Europe.

Various factors are responsible for this supremacy of European industry. One of the most important is the possession of vast quantities of mechanical energy. Cheap power is as fundamental in modern manufacturing as were the skilled artisans in the old handicraft days. Of the power resources which motivate world industry only three are of importance—coal, water-power and petroleum. Of the world production of these in 1927, Europe accounted for 49 per cent. of the coal, 46.7 per cent. of the water-power and 8.4 per cent. of the petroleum—figures of great significance considering that that continent contains only about 7 per cent. of the land area and 30 per cent. of the population of the world.

Evaluation of Power Resources

In attempting to evaluate the importance of these various energy supplies one is confronted with a puzzling variety of units used in their measurement. Obviously "barrels" of petroleum can not be directly compared with "horse-power" of waterfalls or with "tons" of coal produced. Since "tons" of coal are the most familiar it would be convenient to express the quantity of petroleum or the number of horse-power developed in terms of the amount of coal which, when burned, would deliver an equivalent amount of power.

On the average it has been estimated that 5.4 short tons of bituminous coal or 2.68 barrels of petroleum[1] consumed in the average power plant will deliver a horse-power for a year. Likewise a ton of lignite is considered to be equivalent to 2/9 of a ton of bituminous coal. Using these conversion factors and applying them to the production of coal, water-power and petroleum, it becomes possible to view the various parts of the world in true perspective from the standpoint of their power production.

Table I, showing the production of power in terms of coal of the various continents in 1927, indicates the dominant position of North America and Europe. These two account for about 90 per cent. of the world total. The United States alone produces almost one half (48.5 per cent.) and Europe contributes about two fifths (41.8 per cent.) of the whole.

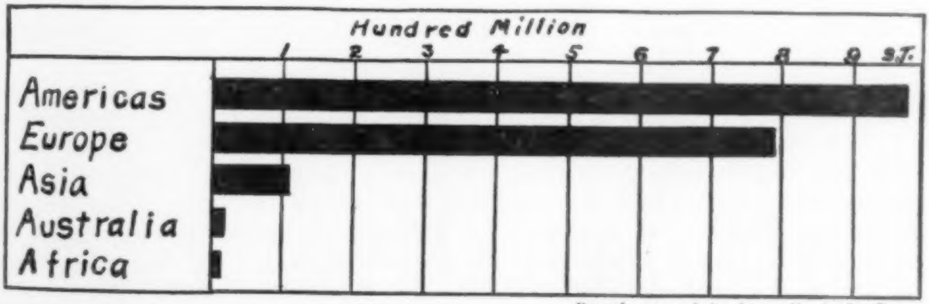
In Fig. 1 we have the same data plotted on the basis of the character of the energy produced rather than the regional distribution. This shows the

[1] U. S. D. C. Yearbook, 1926, Vol. I, p. 262.

TABLE I

MECHANICAL POWER IN EUROPE REDUCED TO COAL EQUIVALENT

	Coal and lignite in terms of s. t. of coal	Petrol. in terms of s. t. of coal	Water-power in terms of coal	Total coal equiv. in s. t.
Albania	....	....	5,400	5,400
Austria	897,600	....	1,755,000	2,652,600
Belgium	27,852,000	....	3,780	27,855,780
Bulgaria	352,000	....	97,200	449,200
Czechoslovakia	20,553,500	35,714	837,000	21,426,214
Denmark	....	....	59,400	59,400
Esthonia	....	....	91,530	91,530
Finland	....	....	1,188,000	1,188,000
France (including Saar)	71,870,700	113,000	10,800,000	82,783,700
Germany	194,088,400	160,000	5,940,000	200,188,400
Greece	29,700	....	43,200	72,900
Hungary	2,333,100	....	16,200	2,349,300
Irish Free State	....	....	....	....
Italy	526,900	10,714	12,420,000	12,957,614
Jugoslavia	1,076,900	....	972,000	2,048,900
Latvia / Lithuania	....	....	27,000	27,000
Netherlands	9,566,700	....	810	9,567,510
Norway (including Spitzbergen)	440,000	....	10,260,000	10,700,000
Poland	39,342,600	1,391,429	486,000	41,220,029
Portugal	138,600	....	54,000	192,600
Roumania	984,500	5,528,571	162,000	6,675,071
Russia	28,927,800	14,986,000	1,485,000	4,398,800
Spain	6,612,100	....	5,400,000	12,012,100
Sweden	290,400	....	7,290,000	7,580,400
Switzerland	....	....	9,990,000	9,990,000
United Kingdom	272,873,700	714	1,350,000	274,224,414
Total	678,757,200	22,225,428	70,733,530	771,716,862

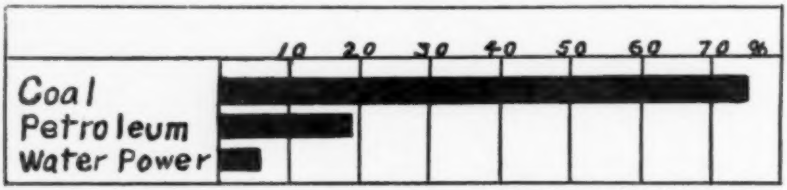


Based upon data from U. S. D. C.

FIG. 1. POWER PRODUCTION OF THE WORLD IN TERMS OF COAL IN 1927. PRACTICALLY ALL OF THE TONNAGE CREDITED TO "AMERICAS" IS CONTRIBUTED BY NORTH AMERICA. THE UNITED STATES ALONE ACCOUNTED FOR OVER 90 PER CENT. OF THE TOTAL FOR BOTH THE AMERICAS.

all-important rôle played by coal. It is responsible for 75 per cent. of all power, while petroleum and water-power contribute 19 per cent. and 16 per cent. respectively.

the much-advertised water-power of Switzerland. The coal of Spitzbergen widely heralded as solving the fuel problem of Norway actually contributes but 5 per cent. of the latter's power. It



Based upon data from U. S. D. C.

FIG. 2. WORLD PRODUCTION OF POWER IN TERMS OF COAL IN 1927 ARRANGED BY SOURCES.

is interesting to note that even within the "water-power belt" such countries as Spain, Jugoslavia and Austria, whose waterfalls are commonly considered as practically the chief reliance, actually depend for about one half of their power upon their coal mines.

Fig. 2 shows the power distribution in 1925–26[2] for the countries of Europe. The dominant position of the great coal-producing countries—Great Britain, Germany and France—is striking. These three countries comprise only one eighth of the area but account for almost two thirds of the total power and two thirds of the total manufactures of all Europe. In general it will be noted that the zone of large power production runs through central Europe from England to Russia—the belt in which coal provides the motivating force. Flanking this coal zone on the north, is Scandinavia, on the south, the Mediterranean countries, both regions of minor importance and relying chiefly upon water-power. In only one country of Europe —Roumania—is petroleum the most important energy resource. In Europe as in the world as a whole it is largely coal which motivates industry.

The map and the data upon which it is constructed furnish a basis for further interesting comparisons which may serve to correct false notions. Thus the coal and lignite output of the Netherlands of which the world hears little are shown to approximate in present importance

Reduced to a per capita basis the power map presents a marked contrast to Fig. 2. Viewed thus (in Fig. 3) Norway ranks second only to the United Kingdom; Belgium is slightly larger than Germany and Switzerland exceeds France. In general the mountainous countries, rich in water-power resources but with sparse populations, show a large per capita output. Russia with its large population but retarded power development is reduced to insignificant proportions.

The power map is of course not an accurate index of industrialization since it represents *output,* not *consumption* of power.[3] England and Germany export much power as coal, Norway and Switzerland considerable quantities as electric current. On the other hand Italy imports more power as coal than she produces from her harnessed water-

[2] Data for 1926 were used where available except for Great Britain where the coal strike made that year abnormal.

[3] The per capita consumption of fuel for heat and power in England, which leads all European countries, is about 4.5 tons; in the United States it is approximately 8 tons.

falls. On the whole, however, the dominant position of coal in the power world and the high cost of its transport gives the countries producing it a tremendous advantage in international markets for manufactures.

It may be contended that since the original supply of coal is definitely limited while water-power is permanent that the coal countries have the advantage only temporarily. However, for the chief coal-producers the reserves are so large and their power production is so far in the lead that there can be little fear of their losing their place for many years to come. This is especially true in view of the marked improvement in efficiency of coal consumption and the superior adaptability of that fuel for industries requiring much heat, such as smelting.

On the other hand, it is interesting to note the rapid increase in relative importance of both water-power and petroleum in the power world during the past few years. The petroleum output in 1927 was nearly two and a half times that of 1913, while water-power development has increased by almost half since 1920. The United States, Canada and Europe have been very active in hydroelectric development, but European activity, at a high level during and just after the war, has slowed down. The cost of water-power installation is high and with the necessity for exploitation of less favorable sites it is bound to become higher. War impoverishment

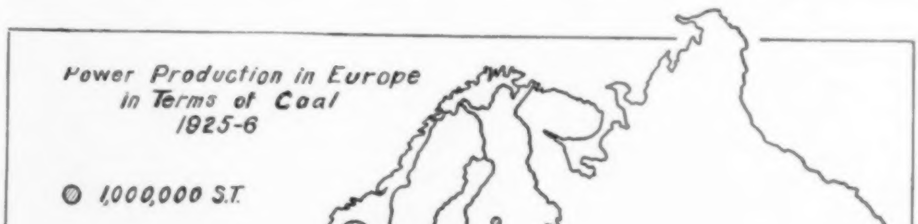


FIG. 3. NOTE THE IMPORTANCE OF THE COAL-PRODUCING COUNTRIES IN POWER PRODUCTION. THREE COUNTRIES ACCOUNTED FOR ABOUT 75 PER CENT. OF THE EUROPEAN OUTPUT.

and dearth of capital are conditions better suited to the use of coal. The "age of white coal" and the "age of oil" of which so much is heard are not with us yet. All of the water-power of the world developed to date (about 3 per cent. of the total potential) is replaceable by only about 116 million short tons of coal, a little more than the yearly output of the state of West Virginia, while all the world's petroleum production is equivalent to the combined coal output of but two states—West Virginia and Pennsylvania.

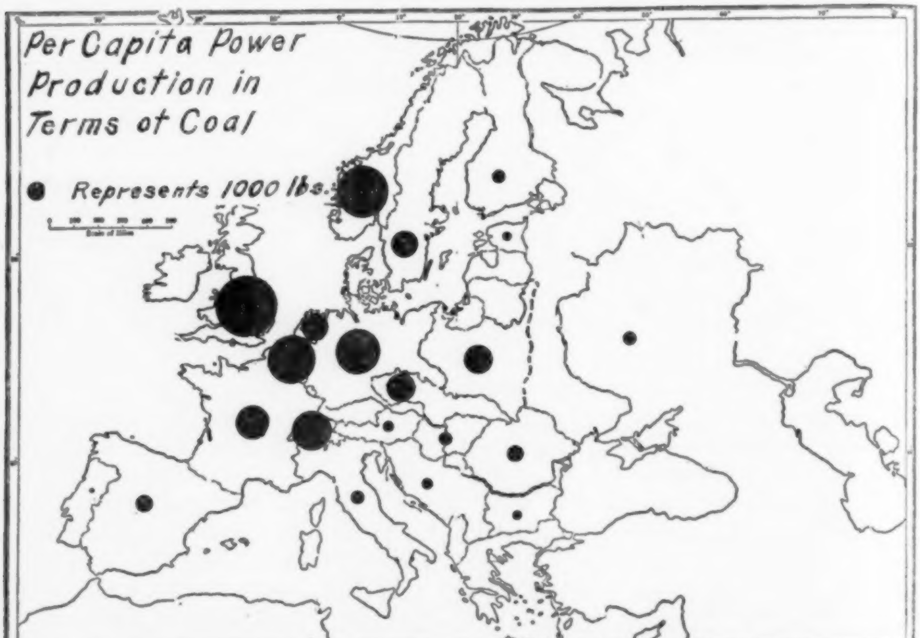


FIG. 4. THE MOUNTAINOUS COUNTRIES SUITED FOR LARGE WATER-POWER PRODUCTION BUT UNSUITED FOR DENSE POPULATION SHOW A LARGE PER CAPITA POWER OUTPUT.

FAMILY AND CONJUGAL AFFECTION AS A FACTOR IN HUMAN EVOLUTION

By RALPH E. DANFORTH

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It is surprising to see how many intelligent people have the impression that the eugenics program slights the value of *love* in family ties. Doubtless there are eugenists who have not thought much about the rôle of affection, but I imagine that the cause of this popular misconception may be due to the fact that the average writer or speaker on eugenics takes the importance of love so much for granted that he either omits to mention it or passes it over with a few words, such as: "Of course, conjugal love is only strengthened and made more permanent by judicious selection of mates worthy of parenthood and general high esteem."

On the other hand, the public is proverbially suspicious of new truths, and smells taints and dangers in discoveries of the soundest worth. To this all history attests.

Eugenics comes in for its full share of the public suspicion, and perhaps the commonest complaint is that it would do away with all love.

An objection often raised is that we should leave all matters concerning the heredity of coming generations to God, that he is taking care of that, and we need not think about it. This second objection I hope also to treat, though briefly, before closing this paper.

Zoologists have long studied the many interesting cases of parental care and affection shown by many species of animals, high or low. Many birds mate for life; many keep within sight or hearing of the mate year in and year out. Our own class, the mammals, universally care for the young for a while, although many species have but fleeting affection for their mates. We need not add that some human mammals have been known to suffer this same lack. Even among the lower or cold-blooded vertebrates remarkable cases of parental care for the young are not infrequent among the amphibians and fishes. Insects and other invertebrates exhibit some striking examples of parental solicitude.

All such cases—and particularly in the higher vertebrates and man, care, affection and love, where such exist—are admitted by scientists to have a very important bearing on the evolution of the species, giving it certain advantages not possessed by species or individuals not exhibiting such care, affection or love.

We may safely conclude that the higher love for mates, for children and for family which we find quite commonly in the human species has been an important factor in our attaining our present superiority. Instinctively also we estimate the relative superiority of people not only by their intelligence but also by their superior endowments in affection and in kindness. Unselfish love is coming more and more, as history advances, to be esteemed a supreme gift.

Family and conjugal affection, having done much to bring us to our present stage in our racial and our family evolution, will be needed even more in future generations to bring us toward that perfection for which we earnestly aspire.

In dealing with a subject like evolution we can not too often remind ourselves that however interesting our evolution in the past may have been, it is our evolution in the present and future which most vitally concerns us. Our

interest in this should be a hundredfold greater than in that which has gone before and is now only a record of what is done and finished for all time. History is interesting and is also a useful source of many suggestions for practical use in the present and future, but what we are now achieving and what we are preparing to achieve and to become are worthy of our intensest application.

No thoughtful person considers the human race at all complete or perfect in its present state. Our conception of an all-wise God would be compromised if we thought he had finished his creation of man, knowing, as we do, how imperfect mentally even the smartest and best of people are. Physically and morally also the race needs improvement, while spiritually the room for growth is infinite.

God's creation of man is still in process.

Many are the factors being used in the process of building up man into the being he should be. Intelligence, common sense, discretion, language, ambition, hope, purpose are a few of these factors. Family and conjugal affection is one of the essential factors without which human evolution can not continue in an upward direction.

Real, true, abiding love for one's mate is absolutely essential for the happiness of the family and the welfare of society. This quality of deep, enduring love should be assiduously sought after in selecting a mate. Without this love there should be no marriage. An inexpressible, deep and beautiful love should grace every matrimonial union. To produce a race devoid of these priceless traits would be a eugenic calamity, an evolution backward. These facts should be more clearly emphasized by eugenists than they have been hitherto, if we would allay ignorant opposition on the part of the well-meaning public. True love, so far from being foreign to the program of eugenics, is one of the most vital factors in human evolution and will be increasingly so as the race rises to higher and yet higher levels.

True love and the eugenic selection of a mate, so far from being antagonists, are the strongest of allies. Nothing could be more absurd than the thought that the use of a little discretion and common sense in the selection of one to whom one will be inseparably bound for life is a killer of love.

For the love of a thoughtful and capable person to endure and to deepen with time there must be worthy qualities in the one loved, qualities which appeal not only to his love but also to his respect and admiration. He or she will, sooner or later, find love giving way to chagrin when there comes the realization of a general lack of worthy qualities on the part of the mate. The best way to forestall this falling off of love is to make sure that the mate is in every way worthy of the deep love bestowed. The best guarantee that love will grow deeper with time, throughout one's wedded life, is a judicious exercise of care as to whom one should marry. To say that this is a joy killer, a stifler of love, is farthest from the fact.

Many who are inclined to look askance at scientific innovations readily pin their faith on time-honored popular mottoes. One of the truest popular mottoes is, "Marry in haste to repent at leisure." In this the "haste" refers not so much to speed as to lack of thought and discretion. One can hardly marry too quickly when sure all is right. For the unscientific type of mind this motto furnishes an excellent working basis for eugenics. This repenting at leisure is most hostile to true love. Those who have thought eugenics a love-killer had better open their eyes and their hearts to eugenics as one of

love's most fundamental allies. Eugenics is the making sure that one is worthy of being loved. Eugenics ascertains, as far as possible, beforehand that there are qualities making for the permanence and increase of love. Eugenics discourages loveless matches, which are made far too often by the unscientific for material or sensuous or selfish motives, and would encourage and insist that there should be true love and real merit deeply rooted in both of the contracting parties.

Eugenics is, in part, a sincere effort to ascertain what good qualities are in an individual. In studying the individual person its methods are twofold. It finds out the real worth of the person by studying the person. To this study of the person himself it adds the study of the performance record of his parents and grandparents, and, when possible, of his great-grandparents, not so much to see if there was any evil in them as to find out how much good was in them as registered by their achievements. We expect to find some worthless or mediocre ancestors in every such search, for there are, as yet, no families so well-weeded as to be without them. But we have a right to expect that a truly worthy person should have a goodly proportion of ancestors who have achieved useful deeds, lived nobly and served their community unselfishly. Eugenics wishes to prove that the individual person possesses physical, intellectual and moral traits which are both excellent and capable of being transmitted by heredity to the generations yet to come. The finding of some flaw or imperfection in the ancestry need not kill all love, as some would fear, but the superabundance of foolishness or selfishness of the ancestry, or too large a proportion of such undesirable ancestors might rightly prejudice one against his budding affection. On the other hand, the finding of a goodly proportion of excellent, intelligent, healthy ancestors of the loved one would rightly enhance the love, confirming the personal judgment of the merits of the loved one. One could then love more ardently than ever and feel pretty confident that as time passes one will never regret the choice.

Eugenics then may fittingly be called the handmaid of true love. The higher we rise, as a race or as a family, the more intelligence is required in our everyday life, in our business, in our eating and in our exercise. Increasingly more intelligence will also be required in our choice of lovers. This is only in keeping with the required increase of intelligence in every other department of our life.

Love and affection are the most beautiful elements in all the universal range of beauty. Sordid indeed and low would be the life without love. A most disgeneric individual would he be who had no appreciation for love of the truest and deepest sort. Such people would be among the first to discard in our eugenic selections. Among the qualities one would seek are health, beauty, intelligence, power to succeed, honesty, cheerfulness, tact, faithfulness, love, in rising scale of importance. These qualities should be well represented in the individual loved and also found in a good *majority* of his or her ancestors.

As the future generations pass, under the eugenic plan, one could insist upon increasing excellence of ancestry, because the eugenic selection would gradually and steadily reduce the inferior ancestral minority and increase the superior ancestral majority. The quality of each succeeding generation born into the world would improve, although for some time to come some black sheep would occasionally recur. Many semi-black sheep or only moderately desirable persons would recur, but in time

even these would tend to give place to the truly superior individuals. These should become ever healthier, brighter and more loving as the centuries roll on.

I hope that the reader can see clearly that the exercise of wisdom and vision in selecting lover and mate is an aid, not a hindrance, to true love. The other objection often raised, that we should leave all such considerations to God to take care of for us, is not in line with our intelligent Christian living in any of the other departments of our life. We do not leave entirely to God the provision of our food and all its preparation for the table; we do not expect Him to fit and sew our clothes and then dress us each morning; we do not ask Him to run our business without any thought or cooperation on our part, or our professions or our homes. We take it for granted that He gave us brains and hands to use rather than for purely ornamental purposes. Our brains certainly are not ornamental. We do not leave all our courting and love-making to God. If we lay all the results and consequences of our courting and love-making to God, in order to be consistent we should also let Him attend to the courting for us, with no cooperation whatever on our part. Now the true Christian believes that God is truly interested in the success of his life, his business and his family and that God expects him to do his part to make all these a success, to use hand and head and heart to bring about this success. The use of at least the same amount of intelligence and forethought in courting as in the less important branches of activity is demanded by common sense and by love alike. We have no right to blame God for the fools born into the world if we make fools of ourselves at the very fountain of life. The Creator is wonderfully patient, but perhaps there is a limit to His patience even in His great plan for the uplift of the human race.

In the title of this article I purposely link together *family and conjugal affection* as one entity. One capable of the loftiest love of mate will also have deep love of family. Far too many people are deficient in the true, abiding love for mate and for family. Family is more than father, mother and children; it is *clan*. This includes a group of related families, with an extensive ancestry reaching back into the past, and an extensive progeny reaching forward into generations to come. There should be more love and loyalty to mate and to family. Family is like a great river made up of numerous streams of mingling waters. When one selects a mate unwisely one not only dishonors one's own personal family, but one dilutes the greater family stream or may even thus pollute it. One thus dishonors true love and dishonors the family.

One belonging to an intrinsically noble family, whether it be ranked with the "nobility" or not, honors and makes more noble that family by every wise choice of superior blood and brain and heart and soul.

Family and conjugal affection is one of the greatest factors in the future evolution of man.

In this wonderful age of science in which it is our privilege to live, each day brings forth new wonders, life becomes richer by each discovery and invention, methods change and our outlook upon life and the world changes with them. These all go to make up part of what we call our "civilization," but they do not change our real selves. It is conceivable that civilization might advance while we were retrogressing. But all our innovations and new knowledge may be used to beautify the world we live in and make it more healthful and pure. May we so live and so love that the species and the environment may both improve together. So far at least as our own family is concerned let us love and toil for its upbuilding.

A MILLION YEARS OF EVOLUTION IN TOOLS

By MILDRED FAIRCHILD and Dr. HORNELL HART

BRYN MAWR COLLEGE

In the attempt to measure past changes in human culture the longest and most complete series of data available consists in the tools with which man has cut and shaped his materials. This series extends in unbroken line over immense stretches of time. Flints chipped by human hands into crude cutting blades have recently been shown to belong to geological strata laid down in England about 1,300,000 B. C.[1] Between these oldest of man-made blades and the most modern cutting devices of Pittsburgh machine shops there is available a practically unbroken series of cutting tools, dated with sufficient accuracy to permit an objective analysis of the relative rates of progress in their efficiency at various points in this tremendous sweep of time.

That progress in cutting tools has been going forward at an accelerating rate is evident from a series of blades representing the various cultural epochs. Fig. 1 offers sketches of artifacts for such a series. Beginning at the lower left-hand corner, and reading up, we have in the first column four cutting blades representing the development of man's facilities for cutting and shaping materials during the nine hundred thousand years roughly from 1,300,000 to 400,000 B. C. The lowest of the four is a sub-Red Crag rostrocarinate flint from Bramford, England. Such flints belong to the Eolithic, or "Dawn-Stone" Age. Also included among Eolithic flints (though not represented in this chart) are the types found at Foxhall, England, dating perhaps one hundred thousand years later than the sub-Red Crag. Still later, though belonging also to the preglacial Eolithic level, came the flints associated with the skull of the "Dawn Man" found at Piltdown, England.

The second drawing from the bottom in the left-hand column of Fig. 1 represents a specimen of the giant flints found at Cromer, England, in strata contemporaneous with the first glaciation, between 900,000 and 800,000 B. C. At about 700,000 B. C., in what is now France, occurred a culture level not represented in the chart, known as pre-Chellean. The third flint in the chart is a Chellean tool.

If the Chellean, pre-Chellean, Cromerian, Piltdown, Foxhallian and sub-Red Crag flints were shuffled and presented to the reader, it would require the closest study for him to determine which of them came first, so slow was progress in cutting tools during the seven hundred thousand years which they represent. The Acheulean and Mousterian, however, begin to take shape in a way which puts them at once, even for the layman, above the cruder flints which preceded them.

Upper Paleolithic, comprising Aurignacian, Solutrean and Magdalenian cultures, was the time of the Cro-Magnon race. Solutrean tools are represented in the chart by the beautiful "laurel leaf" type of blade. The Magdalenian is represented by a flint knife which, instead of being elaborately chipped out like its predecessors, was struck off at one blow with little or no

[1] Henry Fairfield Osborn, "Man Rises to Parnassus," pp. 23–5, 1928.

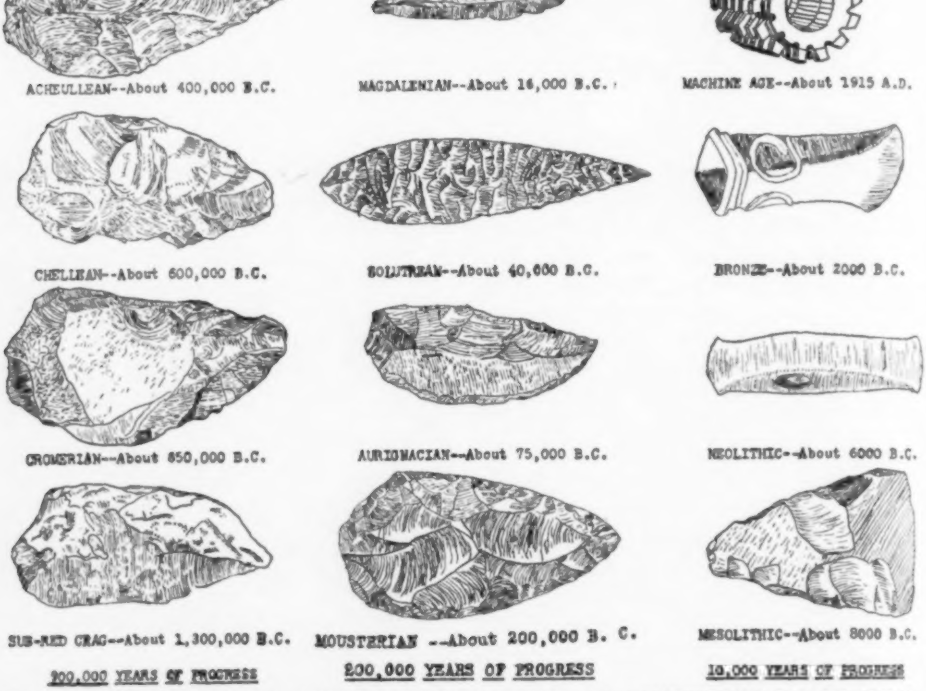

FIG. 1. ONE AND ONE THIRD MILLION YEARS OF EVOLUTION IN CUTTING BLADES.

retouching, in a highly skilful and time-saving way.

The Mesolithic, or Middle Stone Age, includes a variety of cultures. Its representative in the chart is a stone axe-head from Campigny, France. The distinctive feature of this cutting tool is that the edge is partly ground down to sharpness instead of being merely chipped out. The Neolithic specimen carries this development to its logical conclusion and has a completely ground and polished stone axe-head. Leaping over the Copper Age, and many intervening steps in that and the Bronze Age, the next specimen is a socketed bronze celt. Leaping again over the Iron Age, the sketch at the top of the right-hand column in the chart represents a complicated blade used in modern machine-shops for cutting worm gears out of steel.

Without in any sense casting reflections on the prehistoric craftsmen who developed the Acheulean and the Mousterian tools, it seems fairly obvious that the absolute progress in the efficiency of cutting blades during the past ten thousand years in Europe has certainly not been less than the progress during the first million years in the series. If this is true it means that the rate of progress in the last column is at least one hundred times as great as in the first column. Such a conclusion is of fundamental importance—so much so, indeed, that it drives the investigator to ask whether this tendency can not be more accurately measured.

If a quantitative statement of progress in cutting tools is to be made, the first problem is to arrive at the nearest feasible approximation to an objective scale of points by which to rate such tools. Analysis indicates that at least five variables enter into the efficiency of man's cutting tools: (1) Keenness and durability of the cutting edge; (2) differentiation and specialization; (3) effectiveness of mechanisms employed to apply the blade to the materials to be cut; (4) utilization of auxiliary power, and (5) mastery displayed in the technique of manufacture.

Keenness and durability of cutting edge may be represented on a performance scale of which three levels may be defined and dated with fair accuracy. The lowest test is flaying the skin from a dead animal, for which two points out of a possible 20 may be allowed. For blades capable of chopping down trees, five points may be allowed. The highest degree of keenness-durability thus far attained is fairly well represented by the capacity of the cutting blades in a modern machine tool to cut cold steel, or, taking the extreme of delicacy instead of the extreme of strength, the capacity of a modern microtome to slice off cross-sections one twenty-five thousandth of an inch thick for microscopic slides. These degrees of attainment may conservatively be rated at twenty points.

The application of this scale to the series of blades from earliest prehistoric times down to the present produces the ratings in column 3 of Table 1. Before Acheulean times flint blades had the crudest sort of rough cutting edges, very easily dulled by use even against hard wood. Acheulean, Mousterian, Aurignacian and Solutrean blades progressively developed more and more accurate "retouching," whereby the cutting edge was made keener and keener by taking off small chips from the margin. The Magdalenian blade produced a fragile but sharp edge at one stroke. The Mesolithic *tranchet*, or flint axe, with its edge sharpened by grinding, gave craftsmen for the first time a tool capable of felling a tree and of hewing out a log canoe.[2] Further developments of this grinding process in Neolithic times made possible the use of harder stones and the production of keener and more permanent cutting edges. Copper working introduced for the first time metal blades, and the development of bronze made available a more durable and keener edge. Iron and steel brought cutting power which was for centuries regarded as magical. Modern methods of alloying, hardening and sharpening have produced the supremely strong and delicate edged blades of to-day.

The second criterion—differentiation and specialization of tools—is an indirect index: the greater the variety of tools, and the greater the extent to which they are adapted to specific cutting processes, the greater is the efficiency of each tool apt to be. The best comparative study of specialization in Paleolithic tools is given by Osborn.[3] His tabulation shows that pre-Chellean culture had such tools as knives, planers, scrapers, borers and hammer stones. The Upper Paleolithic made huge strides forward. It added chisels, etchers and graving tools of flint; it developed a wide variety of bone implements, such as the spatula, shuttle, pin, needle, wedge and awl. It added such weapons as the barbed dart and harpoon. The Magdalenian period had nearly seven times as great a variety of flint and bone tools as the pre-Chellean. The Azilian (one of the Mesolithic cultures) dropped to a little more than half the variety of the Magdalenian. The Campignion, however (another Mesolithic culture) added to the toolbox of the Paleolithic artificer the pick and the stone axe with a ground edge.

[2] "Man Rises to Parnassus," p. 113.

[3] "Men of the Old Stone Age," pp. 270–1, 1916.

Mesolithic at its best, therefore, represents further progress.[4]

The metal ages opened up new possibilities in tools, greatly accelerating the tendency toward specialization. The Egyptians passed into the Copper Age about 3100 B. C. Copper saws made it possible to cut out the great blocks of stone for the pyramids. The Bronze Age developed fully in Egypt about 2400 B. C. As late as 2100 B. C. stone was still employed for the cheapest of knives used by the fellahin for chopping up meat, and for the arrow-heads which once shot off would never be recovered. Razors and fine daggers, however, were now of finely-tempered bronze, while ordinary knives and weapons were of copper.[5]

As the metal ages proceeded a greater and greater variety of tools became possible. Some idea of the rapid introduction of new forms may be gained from the fact that during excavations on the site of the prehistoric village of Glastonbury, England, which flourished in the Iron Age, about 800 B. C., there were found daggers, spear-heads, swords, knives, bill-hooks, sickles, saws, gouges, adzes, files, bolts, nails, rivets, keys and bits.[6]

Rich as was the variety of tools in classical times, recent developments outshadow the past in this respect as much as in keenness. Consider the catalogue of the modern wholesale hardware dealer in comparison with any inventory of ancient implements. Think of the bewildering variety of tools in the cabinet of a modern dentist or surgeon; examine the kit of the cabinetmaker; enumerate the implements of the engineer or miner, or even the butcher of to-day, and the past specializations of tools fade into relative insignificance. We have special cutting devices to trim off the edges of great piles of book pages, to slice off paper-thin sheets of ham, to sheer a steel rail, to bore a hole under the Hudson, to scoop out a Panama Canal, to cut at one time the pieces of cloth for a score or more of suits, or to bore a well in an oil field. Even fire and chemicals play their part as controlled cutting devices; the oxyacetylene torch eats swiftly through hardened steel; dynamite tears out stumps and splits off coal or granite.

The third variable to consider in rating the efficiency of prehistoric, ancient and modern cutting tools is the effectiveness of the devices employed for giving the cutting blade the desired motion through the material to be cut or shaped. The earliest flint blades were, apparently, grasped merely with the bare hands of the craftsman. The first step toward a mechanical device for directing the blade was hafting—attaching the flint by means of withes, tendons or rosin to the ends of sticks used as handles. Because of the perishable nature of such attachments and because the earliest hafted blades may not have been shaped perceptibly to accommodate their handles, the exact period at which hafting commenced is doubtful. Generally it is thought to have begun late in lower Paleolithic; there is no question that Aurignacian, Solutrean and Magdalenian flints had handles.[7] A further refinement of hafting occurred in Magdalenian and particularly in Mesolithic times, when the composite tool was developed. This consisted of small flint teeth (microliths) which were set into bone or wooden handles to form harpoon heads, saws, and, in Neolithic times, sickles.

More impressive as mechanical devices were the early drills. Rotary motion in blades for boring was first secured by

[4] R. A. S. Macalister, "A Text-book of European Archaeology," p. 552, 1921.

[5] "Cambridge Ancient History," Vol. I, p. 319.

[6] Quennell, "Everyday Life in the New Stone, Bronze and Early Iron Ages," p. 185, 1923.

[7] Kroeber, "Anthropology," p. 178, 1923.

twirling the drill handle between the palms. Then came the idea of twisting a string around the handle and obtaining the whirling motion by pulling the string. By late upper Paleolithic times the bow had been invented and was being used, by giving its string a turn around the shaft of a drill, to produce rotation. The crank drill, with stone fly-weights to keep it whirling, was invented in Egypt between 3400 and 3000 B. C.[8] The drill brace was used by the Assyrians in the seventh century B. C.[9] Another device for rotating cutting edges was the circular millstone, invented in the Iron Age.[10]

Another class of mechanical device whirled the material to be cut or shaped instead of twirling the cutting blade. The earliest machine of this sort was the lathe. Its original form was a development of the bow drill, which probably evolved in the Bronze or early Iron Age.[11] A kindred device was the potter's wheel. This appeared in Egypt before 3000 B. C. and was evidently used much earlier in Elam.[12]

Handles and whirling devices practically exhaust the prehistoric and ancient contributions to the solution of the problem of imparting mechanically the proper motion to the cutting blade and material. Very little progress in this field occurred in medieval times; the wheel-driven lathe giving a constant rotary motion to the wood was a novelty as late as the 14th and 15th centuries: the predominant type was still the strap lathe, in which the piece to be cut was whirled alternately forward and then back.

The real development in mechanical devices for controlling cutting blades has occurred since the beginning of the industrial revolution. In woodworking, for the quantity production of such objects as gun stocks, the modern mill has copying lathes which automatically turn out any shape desired. The same thing is done in metal working. Into one end of an automatic machine are fed steel rods or sheets; out of the other end, without guidance by human hands, come finished screws, bolts, machine parts, or what not. The modern automatic machine thus handles mechanically the entire process of imparting the correct cutting motion to the blade—a process which until two or three centuries ago was almost entirely carried out by direct manual dexterity.

The fourth variable to be rated in sketching the curve of evolution of cutting tool efficiency is the application of power to the tool. During the whole lapse of the stone ages the power applied to tool-driving was entirely human. Rudimentary progress was made in the more effective utilization of this power: the handles applied to stone axes, and the bows employed to drive drills were not merely for the purpose of imparting the desired motion but also for the sake of imparting more power. In Aurignacian times[13] the invention of the bow put at the disposal of the hunter new power for the propulsion of flint-tipped arrows. The spear-thrower, which appeared in Magdalenian times, augmented the force of the human arm.

Neolithic domestication of animals brought new power reinforcement. It was not, however, until the Bronze Age, sometime before 2000 B. C., that the ancient Egyptian first took the step of putting onto his hoe the attachments needed to turn it into a horse-drawn plow.[14]

[8] Breasted, SCIENTIFIC MONTHLY, 9, p. 571, 1919.

[9] *Britannica*, 9, p. 69, 1910–11.

[10] Quennell, *op. cit.*, p. 180.

[11] Quennell, *op. cit.*, pp. 130, 191 and 202.

[12] "Cambridge Ancient History," 1, p. 320.

[13] Sollas, "Ancient Hunters," pp. 356, 359, 1924.

[14] Breasted, SCIENTIFIC MONTHLY, 9, pp. 424–5, 1919.

It was the ancient Egyptians also, according to Quennell,[15] who first harnessed water-power by mounting in midstream a boat with millstones geared to paddle wheels. The ancient Romans worked their millstones by horse-power, slave power, and probably water-power. The early Anglo-Saxons drove their mills by donkey power before A. D. 500. In the eighth century they had mills driven probably by water-power. Windmills began to be used in England as early as A. D. 833. It is supposed that they were introduced from the east by crusaders. The Middle Ages show progressive minor improvements in wind and water mills. Wind-power was harnessed to saws in England about the beginning of the thirteenth century, and it was soon followed by the use of water-power, but opposition on the part of hand sawyers prevented any widespread development of power sawmills until their adoption in America in 1634. A trip-hammer run by water-power was introduced in England in the seventeenth century.

The invention of the steam-engine, and the discovery of coal as a fuel, marked, of course, a new epoch in the application of power to tools. While steam has multiplied overwhelmingly the amount of power available, it has not monopolized the field. The development of the water turbine has given water-power a resurrection of usefulness. The invention of electric generators and the introduction of compressed air devices made possible the application of power to small and isolated tools inaccessible to direct steam drive. Tools used in mining and quarrying, and tools employed in family kitchens, illustrate the new fields opened up by these auxiliary forms of power. The gasoline engine provides another easily moved power unit, which is likely to displace the horse in driving agricultural tools. The old standard for plowing used to be one acre per man per day; the tractor-hauled gang plow does twenty-two acres per man per day. Both in the amount of power available, and in the versatility of its forms, the progress in the past three centuries towers vastly beyond all the developments of the preceding million years.

The accelerating increase in the amount of power available may be illustrated by the fact that at the close of the Civil War the manufactures of the United States employed less than 1.3 horse-power per wage earner; in 1922 3.8 horse-power per wage earner was used. This means that in this country since 1869 more than twice as much power per worker has been added as had been acquired in all the hundreds of thousands of years preceding. During this period, moreover, the increase in horse-power has been accelerating.[16]

A spectacular phase of the accelerating mastery of power is stated thus by Frank Bohn:

> Thirty years ago the best steam turbine on the market used five or six pounds of coal to produce a kilowatt hour of electricity. Two years ago the new unit in Brooklyn used exactly 1.4 pounds. The most efficient new plant now requires only .85 pound.[17]

The remaining criterion of progress in tools relates, not to the effectiveness of the instrument as a means of cutting and shaping materials, but rather to the mastery displayed by the craftsman in the production of the tool itself. That mastery may be judged by at least two qualities remaining in the tool: the standardization of design, and the beauty of form, material and ornamentation.

Before the Acheulean period there is little in the cutting tools of prehistoric

[15] "A History of Everyday Things in England," Vol. I, p. 95.

[16] U. S. Census, Vol. VIII, pp. 14, 15, 22, 1920; *Industrial Management*, Vol. 72, pp. 364–72, Dec., 1926.

[17] New York *Times Magazine*, p. 1, Oct. 2, 1927.

man to suggest handicraft mastery, or indeed, anything which might be called a developed technique of manufacture. Osborn says of the Chellean period that "at this dawning stage of human invention the flint workers were not deliberately designing the form of their implements, but were dealing rather with the chance shapes of shattered blocks of flint, seeking with a few well-directed blows to produce a sharp point or a good cutting edge."[18]

With the Acheulean period, however, specific forms and characteristic designs become apparent. And in the Mousterian, "points" struck off from the flint core with a single blow after a careful flaking and retouching had prepared the surface and edge, show definite technique.

From that time on, with one or two possible exceptions in so-called degenerative periods, a progressively increasing mastery of technique appears. Obviously the artificer acquired more and more skill to take off his flakes delicately at the points which he selected, and to control the shape of the tool he produced. The forms became less haphazard and more standardized; the shapes approached more and more to beauty. By about 40,000 B. C. flint instruments had developed in the hands of Cro-Magnon man to the "Solutrean" level. Instead of being knocked off by sharp blows, the flint was chipped off by pressure in fine, thin flakes from the entire surface of the implement, to which in its perfected form the craftsman could give a keen edge and perfect symmetry. Definite progress is in evidence, but progress attained only during the slow passage of tens of thousands of years.

With the increasing use of bone and ivory as materials the etching of designs, already presumably well started on wooden implements, came into prominence on cutting blades. As tools of bone became more beautiful, flint chip-

[18] "Men of the Old Stone Age," pp. 129 and 152.

TABLE 1

RATINGS OF THE EFFICIENCY OF CUTTING TOOLS AT VARIOUS CULTURE EPOCHS, FROM EOLITHIC TIMES TO THE MACHINE AGE

Period	Date*	Keenness	Specialization	Mechanisms	Power	Technique in manufacture	Total rating
1	2	3	4	5	6	7	8
Machine Age	A.D. 1915	20	20	20	20	20	100
Iron	500 B. C.	16	15	7	8	14	60
Bronze	2000 B. C.	12	13	6	5	13	49
Copper	4000 B. C.	9	12	4	2	12	39
Neolithic	6000 B. C.	7	10	4	2	11	34
Mesolithic	8000 B. C.	5	8	4	2	9	28
Magdalenian	16000 B. C.	4	7	2	2	8	23
Solutrean	40000 B. C.	4	6	2	2	7	21
Aurignacian	75000 B. C.	3	6	2	2	5	18
Mousterian	200000 B. C.	3	2	2	1	4	12
Acheulean	400000 B. C.	3	2	1	0	3	9
Chellean	600000 B. C.	2	2	1	0	1	6
Cromerian	850000 B. C.	2	1	1	0	1	5
Foxhallian	1150000 B. C.	2	1	0	0	1	4
Sub-Red Crag	1300000 B. C.	2	1	0	0	1	4

* These dates all refer to culture stations in England, France and Denmark, as estimated in Osborn's "Man Rises to Parnassus."

ping temporarily declined in technical mastery and beauty. In the Magdalenian period consequently many archeologists label the flint manufacture as degenerate. In this connection it might be well to remember the amazing beauty of the cave painting and engraving belonging to the period. The Magdalenians shared perhaps in the modern tendency to divorce art and technology.

The Neolithic period brought a renewed interest, not only in the new forms produced by the developed technique of grinding and polishing, but in the perfecting of chipped blades. The finest flints of any period belong to the Neolithic and early Copper ages. The technique of flint-working was at its height after metal began to displace flint.

Metal work probably found its earliest developments in jewelry, and it retained its decorative features as it was applied to tools and weapons. Ancient swords, daggers and knives vie with bowls, vases, breast plates and the like as objects of art. The skill and the joy of craftsmanship, moreover, found increasing outlet in the growing variety of forms and materials with which it could work.

The machine age has practically abandoned decoration of its working tools. There is an inherent beauty in the size, power and smooth efficiency of the modern machine tool. There is also increasing beauty of form and line and increasing attention to the attractiveness, as well as the efficiency of the materials used. On the whole, even so, beauty is not a primary characteristic of the modern machine tool.

Mastery of the technique of manufacture, nevertheless, has increased tremendously. With increased complication, large-scale production and division of labor, the joy of craftsmanship has been split up between the designing engineer, the draftsman and the machinist, if not also among a great many repetitive workmen who produce a standard product from a standard design. For the last, the joy of creative variation in their work has been removed. Nevertheless the finished product shows an almost incredible advance in design and perfection of manufacture. And to the designing engineers and to many skilled machinists the delight of fine craftsmanship has remained and, in some ways, has increased.

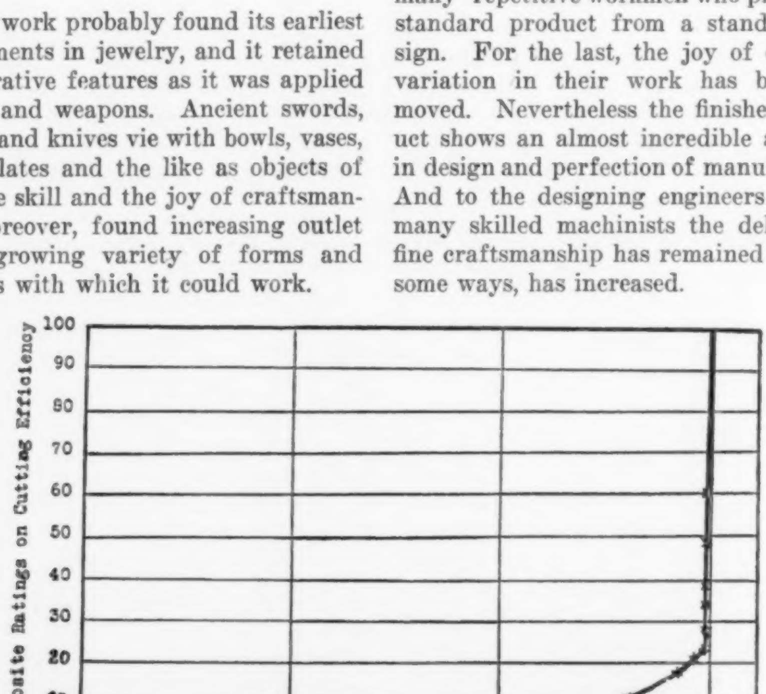

FIG. 2. ONE AND ONE THIRD MILLION YEARS OF PROGRESS IN CUTTING EFFICIENCY.

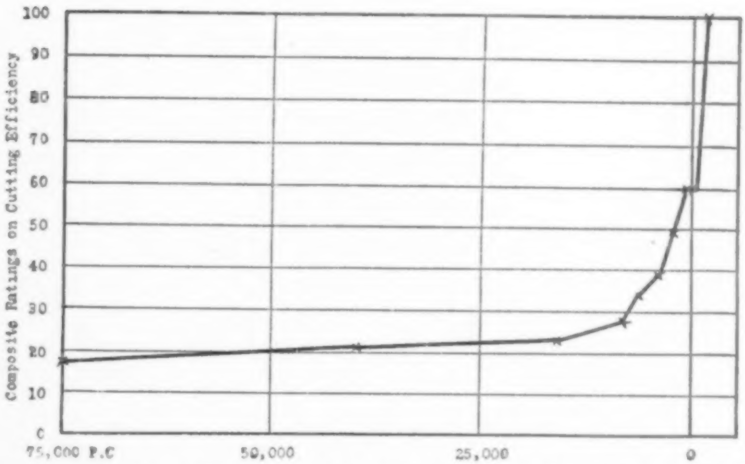

FIG. 3. THE LAST 75,000 YEARS OF PROGRESS IN CUTTING EFFICIENCY.

Reducing the above facts to a numerical basis, in ratings which severally run from 0 to 20, and which in total run theoretically from 0 to 100, the measures of progress presented in Table 1 are obtained. It is not, of course, asserted that these ratings have absolute objective validity; it *is* argued, however, that any intelligent student of the data will come to results so closely approximating these that the practical deductions will not be materially affected. It is suggested that the reader try the experiment of making his own independent ratings of the cutting tools of the different culture epochs, and that he chart the resulting curve for comparison with that given in Figs. 2 and 3.

The ratings presented in Table 1 and Figs. 2 and 3 reflect a rising curve of progress; for hundreds of thousands of years the gains are scarcely perceptible; then tens of thousands, and later thousands of years showed marked improvements. Now we no longer deal in centuries but find each decade or each year taking swift steps forward. The more and more rapid acquisition of new elements is not due to our lack of knowledge of early portions of the series; the increasing speed of invention is an unmistakable feature of the series itself. Except for temporary fluctuations, man's power to cut and shape materials has increased during the past million years at accelerating speed.

THE EVERGLADES

By Dr. JOHN K. SMALL

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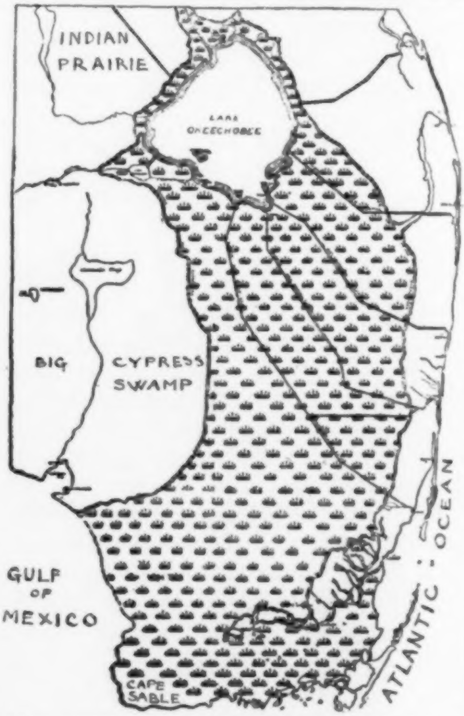
THE Everglades—a unique natural monument and a very misconceived region—occupy about one half of the area of the Florida peninsula lying south of the head of Lake Okeechobee. To the mind of the uninitiated the Everglades are a vast, more or less impenetrable jungle, abounding in reptiles, birds and other wild animals. Nothing could be further from the real state of affairs. However, it is true that there are various intruded and sometimes included plant associations that collectively do harbor more kinds of aquatic, amphibious and terrestrial wild animals than any equal area in North America.

The Everglades lie in a shallow rock basin which falls off rather suddenly from the great Okeechobee prairie on the north and the pineland on the east, and very gradually from the Indian Prairie and the Big Cypress Swamp on the west. The area involved is over four thousand square miles. The acreage has been estimated as high as three hundred thousand.

As a result of the geologic structure of the Florida peninsula the Everglades are really a gigantic spring, perhaps the largest spring in the world. The tributary streams supply the area with a certain amount of water, but a vast amount must come from subterranean sources which follow with a slight southerly dip the nearly horizontal rock strata which underlie the surface of the peninsula. The outflow is certainly far in excess of the visible sources of its waters. The configuration of the surface, which is nearly flat except for the curvature of the earth, and the water supply are ideal for the growth of saw-grass (*Mariscus jamaicensis*). This is the characteristic plant of the Everglades, which are often referred to by the Indians as the "Saw-grass." Indeed, it is the largest saw-grass marsh in the world.

The Everglade prairie begins (at the north) a mile or two north of the head



MAP SHOWING THE EVERGLADES (SHADED PORTION) IN RELATION TO THE SURROUNDING LAND AND WATERS. THE STRICT FORMATION OF THE EVERGLADES IS AN UNINTERRUPTED PRAIRIE, WITH NOTHING IN VIEW EXCEPT SAW-GRASS AND SKY, AS SHOWN IN THE FOREGROUND OF FIGURE ONE. HOWEVER, SUCH A LARGE AREA NATURALLY HAS MANY SPECIALIZED FEATURES. SOME OF THESE ARE SHOWN IN THE ACCOMPANYING FIGURES. LAKE OKEECHOBEE IS ABOUT FORTY MILES IN DIAMETER.

THE EVERGLADES OR SAW-GRASS, WITH FRINGES OF PINELAND ASSOCIATION, OUTLIERS OF THE EVERGLADE KEYS IN THE DISTANCE. FARTHER NORTH IN THE EVERGLADES THE TOTAL LANDSCAPE IS THE SAW-GRASS PRAIRIE. CLOUDS OF SMOKE FROM A PRAIRIE FIRE MAY BE SEEN AGAINST THE SKY.

A WATER-HOLE IN THE EVERGLADES—AN IDEAL CAMPING PLACE FOR BOTH THE RED-MAN AND THE WHITE, BEFORE THE "GLADES" WERE TAMPERED WITH. SUCH DEEP HOLES FURNISHED COOL PURE WATER EVEN DURING THE DRY SEASON.

A SMALL SECTION OF ROYAL PALM HAMMOCK, THE LARGEST OF THE EVERGLADE HAMMOCK ISLANDS, WITH EVERGLADE PRAIRIE IN FOREGROUND. IT HARBORS ABOUT TWO HUNDRED KINDS OF WOODY AND HERBACEOUS PLANTS, MANY FERNS, AND A LARGE NUMBER OF ROYAL-PALMS.

of Lake Okeechobee. It fringes the lake, the fringing area becoming wider southward on both sides of the lake. The main basin has a gentle curve westward. The eastern side follows the rock rim of the eastern coastal region of Florida; its western side follows a nearly similar curve along the Indian Prairie and the Big Cypress Swamp. The Ten Thousand Islands form a kind of delta of the Everglades. There much of the surface-water finds its way to the Gulf of Mexico through a labyrinth of myriad channels. In addition to the delta-like outlet, the measureless water of the Everglades is constantly escaping in numerous surface streams flowing into the Atlantic Ocean, through the coastwise lagoons, Bay Biscayne and the Bay of Florida, through the Caloosahatchee flowing into the Gulf of Mexico, through subterranean streams, some of which show themselves as springs of fresh water off the shores of the ocean or in the coastal saline lagoons and bays, through the honeycombed limestone of sections of the coastwise ridge on the east, through general seepage and through evaporation from a surface of about three hundred thousand acres. These are the natural outlets for the Everglades' waters, not only unmeasurable but also unmanageable on occasion.

The balance of the surface waters and of the water-table, regulated through ages, was normally beneficial to the natural vegetation of the Everglades themselves and all the surrounding territory. With this water protection, climate was tempered and fires, at first a natural calamity as a result of lightning and later artificially started by the methods of primeval man, were relatively rare and evidently circumscribed. Furthermore, the many elevated parts of the Everglade prairie and the islands were tillable during the seasonal period of low water—the winter. Curiously enough the winter is the proper season for the growing of vegetable crops in that latitude. Likewise, under these natural conditions, the water-table was

sufficiently high to furnish vegetable crops and citrus groves with capillary water in the pinelands and hammocks lying between the Everglades and the ocean.

The Everglades were not much traversed by the white man for a period of two generations in about the middle of the last century, or in other words, from the period of the notorious Indian hunters after the first big real estate grab was made more or less successful by an attempt to exterminate the Seminole or remove him from the land, down to the remarkable developments during the first quarter of this century.

The Everglades have, or should we say once had, several floristic features. Their edges are fringed by such natural plant-associations as flatwoods, pinelands, small prairies, or "glades," and hammocks. The latter plant-association, truly a jungle, although really a minor element in the structure of the Everglade vegetation, gave to the general public through superficial observation the erroneous idea of the Everglades. Aboriginal mounds or ruins of aboriginal occupation and civilization are also to be met with on the outskirts and in the interior.

To one who has been through the Everglades, several major elements in its superficial geology and vegetation are evident. At the upper end there is a shallow basin which, always filled with water, constitutes Lake Okeechobee. As the aborigines sometimes termed it Mayami, it appears as Lake Mayami on some of the early maps of Florida. Lake Okeechobee has several features of interest. Its area is second to the largest fresh-water lake within the United States—Lake Michigan being the larg-

CREEK-SEMINOLE INDIANS IN A TEMPORARY CAMP NEAR THE EASTERN EDGE OF THE EVERGLADES. THE GROUP REPRESENTS THREE GENERATIONS IN CYPRESS TIGER'S FAMILY. THEY STILL USE NATIVE PLANTS FOR SHELTER (PALM-THATCH) AND FOR FLOUR (COONTIE).

A SLOUGH IN THE EVERGLADES. A FORK OF THE HEADWATERS OF TAYLOR RIVER WHICH FLOWS SOUTHWARD TO THE BAY. THE WATER, COVERED WITH LILY-PADS AND MAIDEN-CANE, ABOUNDS IN AQUATIC AND AMPHIBIOUS ANIMALS. THE BORDERING HAMMOCKS ARE THE ROOKERIES OF COUNTLESS WATER BIRDS OF VARIOUS KINDS.

A "GATOR-HOLE" IN THE EVERGLADES. SUCH SHALLOW POOLS AND THE ENVIRONS ARE THE HOMES AND DELIGHTS OF THE ALLIGATOR. THE IMMEDIATE SURROUNDING PLANT ASSOCIATION COMPRISES SAW-GRASS, BULRUSHES, AND CAT-TAILS. LILY-PADS COVER MORE OR LESS OF THE WATER SURFACE.

est; it is a kind of counterpart of the celebrated St. Johns River. The headwaters of the St. Johns and those of Lake Okeechobee, the Kissimmee River, rise, the former on the eastern side and the latter on the western side of a rather narrow watershed. The St. Johns flows northward, expands with Lake George, continues and empties into the Atlantic Ocean through an easterly channel. The Kissimmee River flows southward, expands into Lake Okeechobee, and empties into the Gulf of Mexico through a westerly channel—the Caloosahatchee.

Up to a few years ago the rim of Lake Okeechobee, particularly on the eastern side where the strong westerly winds and hurricanes through ages had thrown up some of the lake bottom as a sand beach, a primeval forest—hammock—of gigantic cypress trees and various broad-leaved temperate-region trees, such as the maple, the ash and the elm, and a few tropical trees whose seeds had been sown there by migratory birds, formed a plant-association of indescribable beauty. On the southern side between the open waters of the lake and the Everglade prairie there had accumulated an enormous deposit of humus or decayed vegetable matter apparently unequaled by a similar structure in the United States. This accumulation of humus, essentially a gigantic sponge, covering thousands of acres varying from one foot to several feet in depth, supported an association of pond-apple and elder unique in all of North America. The Everglades south of Lake Okeechobee, say for half the distance to the Bay of Florida, are merely saw-grass prairie, with just the same amount of relief as mid-ocean in calm weather. In the more southern portion the surface is dotted by myriad hammock islands ranging from a small fraction of an acre to several acres in extent.[1]

TEMPORARY CAMP OF CREEK-SEMINOLE INDIANS IN THE EVERGLADES. THE GROUP SHOWS JESSIE WILLY AND FAMILY. A CENTURY OF EXPERIENCES MAKES THE EVERGLADES A SAFE PLACE OF RESIDENCE FOR THE INDIANS. THEY MOVE ABOUT DRY-SHOD OR BY CANOE, ACCORDING TO THE STAGE OF THE WATER.

[1] Some plant geographers consider the southeastern part of the Florida Peninsula lying south and east of the Everglade Keys as

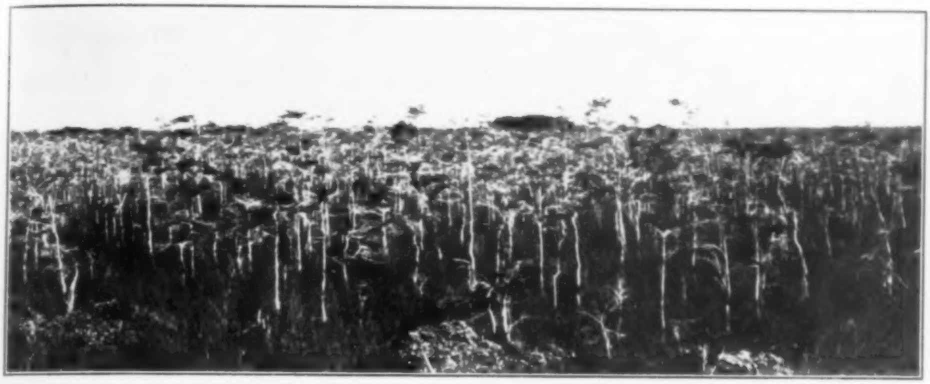
WHERE THE EVERGLADE PRAIRIE MEETS THE BRACKISH AND SALINE MARSHES AND SWAMPS OF THE CAPE SABLE REGION. THOUSANDS OF ACRES ARE COVERED WITH DWARF MANGROVES AS SHOWN ABOVE. TOWARDS THE COAST THE MANGROVE TREES GROW VERY LARGE AND WITH THEIR PROP-ROOTS FORM IMPENETRABLE FORESTS.

Although Lake Okeechobee naturally has a nearly stable water-level, in the greater part of the Everglades the level of the surface-water has normally a seasonal fluctuation. Thus in the rainy season, the summer, the Everglades should be brimful of water; on the other hand, in the dry season, the winter, the surface should be more or less dry. At this period the Everglades represent a low prairie, while in the wet season they really constitute a vast lake. When seen at this high-water stage, some of the early Spanish expeditioners considered the whole basin a vast lake and it was recorded "Lake Mayami."

Various minds have conceived various schemes for the "development," of the Everglades, or "devilopment" as interpreted by some. Among these ideas "drainage" and "farming" have been prominent excuses for tampering with the Everglades, ravishing directly the "glades" and indirectly the whole of the southern part of the Florida peninsula.

Since the beginning of this century five water highways, preliminary to the dredging of drainage canals, have been added to the natural outlets for the enormous amount of water of this spring. The sudden upsetting of nature's routine of ages did not better matters, to say the least. Droughts and "freezes" are said to be now more frequent than formerly. Large areas of land between the Everglades and the ocean are said on good authority to have been rendered worthless for farming by seriously lowering the water-table and eliminating the capillary water-supply necessary for the existence of vegetation, particularly of cultivated crops. Thousands of acres of humus, deprived of the moisture naturally covering the rocky or sandy foundation of the Everglades, have completely disappeared in smoke, gases and

"Front Prairie." By position it is a front prairie, but in no essential way, either in structure, plants or plant-associations, does this one differ from that part of the Everglades lying north and west of the Everglade Keys, except where it is invaded by maritime vegetation.



NEAR THE SOUTHERN END OF THE EVERGLADES WHERE THE FORMATION OF THE BIG CYPRESS SWAMP INTRUDES FROM THE NORTHWEST. IN WINTER, THE MYRIAD DWARF LEAFLESS "EVERGREEN" POND-CYPRESSES RESEMBLE SO MANY SKINNY SPECTERS STANDING FOR MILES ACROSS THE PRAIRIE. THE TREES NEVER GROW PERCEPTIBLY LARGER.

scant ashes, thus turning the Everglades back to a desert just as it was when it was first elevated from the sea.

As some one has recorded: "There will be revelation for the North in the Everglades' conflagration, for millions regard these as but an immense swamp, and how could a swamp burn? Facetiously they may remark that the Everglades need irrigation rather than drainage. The blaze is serious, endangering thousands of acres of rich soil. The fire wardens' forces and others are fighting the flames, and drenching rains would be welcome. Careless hunters or motorists are blamed for starting the fire. No! the crazy drainage schemes are responsible. Nature's building of ages utterly destroyed in a decade!"

The Everglades were made for plants and animals to inhabit and delight in; not for man to occupy. This fact should have been evident to a mere tyro. Man could have enjoyed its uniqueness. When nature has turned loose hurricanes Lake Okeechobee and the surrounding Everglades have taken and will take a larger toll of human lives than the region of the same latitude exposed to the full fury of the ocean.

Aside from any indirect devastation caused by drainage, fire has destroyed the humus on many thousand acres. When once started in the dry humus, fire eats in and down, and burns until it reaches water or sand. Fires aerial and subterranean have eaten away many thousands of acres of pure humus in the Everglades during the past decade and the fires are still burning. The Everglades can safely be termed the "Land of Ten Thousand Smokes." Would it not have been a better plan to have closed this land to "devilopment" and had it appear on the maps of Florida as "Lake Okeechobee—Everglades National Park"?

THOMAS CHROWDER CHAMBERLIN

THE PROGRESS OF SCIENCE

THOMAS CHROWDER CHAMBERLIN

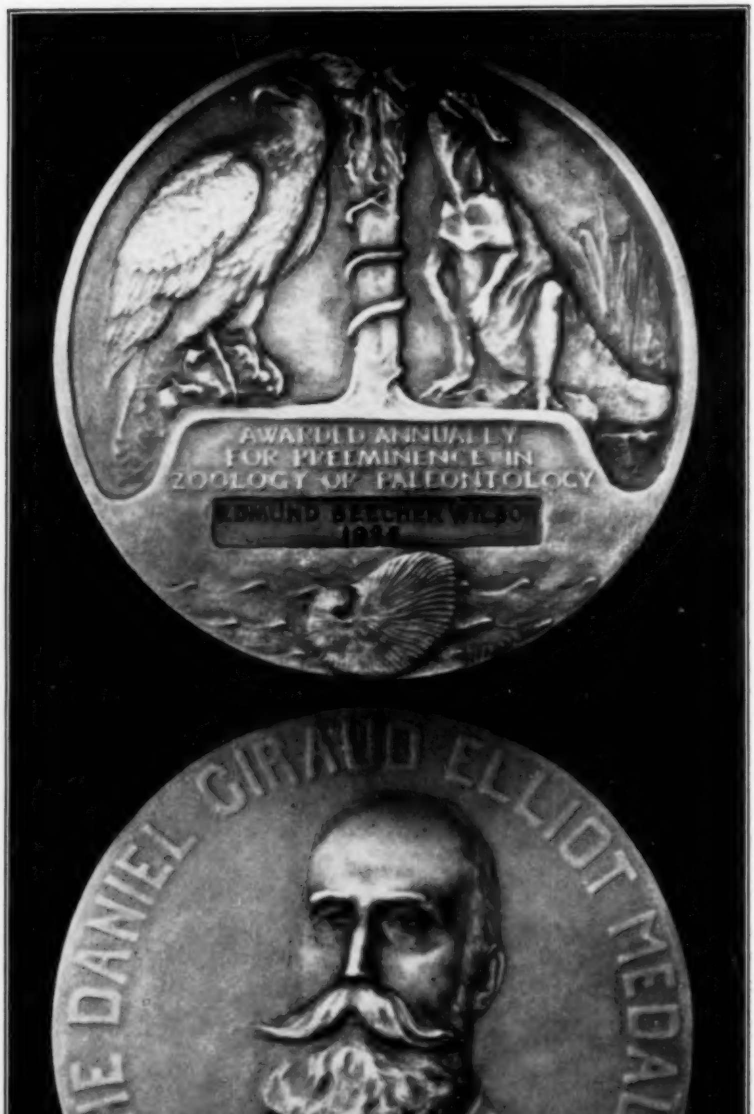
A MASTER of research has passed in Thomas Chrowder Chamberlin. His place is with the greatest thinkers of the past. He leaves few if any equals among his contemporaries. His far-flung research into the processes of the universe is a challenge to younger students to spread wings of imagination toward the unknown—but only with thorough understanding of the course to be flown and constant checking of the navigation.

Chamberlin, the glacialist, geophysicist and cosmogonist, was a geologist in that large meaning which he expressed at the Cleveland meeting, a year ago, in calling upon his colleagues to overleap the bounds of a petrified, terrestrial science. Rocks are not dead. They are to be studied as living assemblages of energy, organized according to the laws of physics and chemistry. He bade geologists explore these domains intensively, as their own. He invited them to penetrate the marvelous cosmogonies of the atoms, where in those intimacies of nature lies hidden the secret of evolution. He unrolled the history of the planet and traced our dynamic descent from our parent, the Sun. His concept of geology embraced the solar system and touched the stars. Fully aware that he could not long sustain the effort, he appealed earnestly to his fellows to carry on in all the fields of the science of which "astronomy is the foreign department."

Chamberlin will always be known as the author of the planetesimal hypothesis of the birth and growth of the Earth. Its fundamental concepts are wholly his. The mutual reactions of the Sun and a passing star in giving birth to the planetary system he reasoned from its orderly movements, as he has more recently argued the erratic origin of comets in the Sun's ungoverned, eruptive activity. These concepts are the survivors of a large number of possible inductions which he investigated, rigorously applying the method of multiple hypotheses. His endeavor was to find a process that would give rise to swarms of planetesimals from which the dynamic peculiarities of the planetary system might evolve. The initial idea of the growth of the planets by a gathering in of planetesimals was forced upon him by the failure of the gaseous and meteoritic assemblages of matter to meet the tests to which he and his collaborator Moulton patiently subjected them.

Some thirty odd years ago he compared the work in which he was engaged to that of a miner exploring an old mine to ascertain what of value might have been left in the old leads. It was not until he had proved them valueless that he turned to new prospects, which he exploited patiently, persistently and critically in discriminating search for the true vein of reality.

In collaboration with the colleagues whom he drew about him Chamberlin was dominant because of the tremendous mental power behind his thinking, but never by assumption of authority. He put forward every idea that his fertile mind conceived. Then he tested each one by natural logic, as his phrase was, and he expected his associates to test his suggestions by every pertinent critical fact or by mathematical analysis. He welcomed a justified destructive critique as clearing away an obstruction to advance. He constantly guarded himself and his fellow students against overconfidence in the verity of his assumptions.



THE DANIEL GIRAUD ELLIOT MEDAL

Shortly before the appearance of his last work, "The Two Solar Families," which reviews his previous work critically and presents supplementary deductions that strongly support the old, at the age of eighty-five, he wrote:

> The most friendly thing I can urge is that you look critically into my logic and my conclusions. I have, of course, great confidence that in all essentials I am in the line of reality, but it behooves others to discount any self-partiality that may creep into my work.

Unfortunately few are qualified by understanding of geology, geophysics and celestial dynamics to analyze, much less to criticize, Chamberlin's contributions to the science of the Earth and the solar system. His philosophy of geology will not bear its full fruitage until a generation shall have grown up free from the inherited theories that he discarded and open-minded toward the new ideas he has inspired.

Chamberlin's intellectual detachment from his own ideas was the more remarkable because he was a man of very strong convictions. He was most conscientiously convinced, however, of the inviolate integrity of truth, and he defended the truth, as facts presented it, from misrepresentation by himself as sternly as from attacks by others.

Of his wide range of contributions to science and of the man himself in his human relations this is not the place to speak. This is but a slight tribute to his greatness from one who has been privileged to walk by his side.

Bailey Willis

PRESENTATION OF THE DANIEL GIRAUD ELLIOT MEDAL TO PROFESSOR EDMUND B. WILSON

By the terms of the deed of gift of the Daniel Giraud Elliot Fund of the National Academy of Sciences, the income of the fund is to be applied to the striking of a gold medal "which together with an accompanying diploma and the unexpended balance of income for the year is to be awarded annually to the author of such paper, essay or other work upon some branch of zoology or paleontology published during the year as, in the opinion of the judges, who shall be Henry Fairfield Osborn, of New York, the scientific director of the American Museum of Natural History, and the secretary of the Smithsonian Institution, shall be the most meritorious and worthy of honor." Owing to the death of Dr. Walcott, chairman of the committee in charge of the fund, no award had been made since that of 1924. Dr. Frank R. Lillie has been appointed chairman in place of Dr. Walcott, and the judges have awarded the medal for 1925 to Professor Edmund Beecher Wilson in recognition of his monumental work on "The Cell in Development and Heredity," and for his many other important contributions to cytology. The chairman of the committee requested Professor E. G. Conklin to state the reasons for the award, in presenting Professor Wilson for the reception of the medal at the dinner of the academy at Schenectady on November 20, which he did as follows:

> Mr. President, I count it a great honor and privilege to present for the Daniel Giraud Elliot Medal a man whom we all delight to honor, one who is recognized throughout the world as a foremost authority in cytology, and one in whom unusual accuracy and precision of work is combined with breadth of view, critical judgment with sympathetic cooperation, the mind of a scientist with the imagination of an artist.
>
> The present science of cytology had its birth during the eighties of the last century, and the first edition of "The Cell" appeared in 1896, scarcely a decade after the epoch-making discoveries of Boveri and Van Beneden. It at once took first rank among books on cytology and contributed mightily to the development of that subject. The second edition appeared in 1900 in a revised and slightly enlarged form,

Bachrach

DR. CLINTON JOSEPH DAVISSON

OF THE BELL TELEPHONE LABORATORIES, ON WHOM THE NATIONAL ACADEMY OF SCIENCES HAS CONFERRED ITS COMSTOCK PRIZE FOR "THE MOST IMPORTANT RESEARCH IN ELECTRICITY, MAGNETISM AND RADIANT ENERGY MADE IN NORTH AMERICA DURING THE PAST FIVE YEARS."

and it has for more than a quarter of a century been a standard reference book in cytology. During this quarter century cytology made wonderful progress, especially in its relation to genetics. It was in 1900 that Mendel's law of heredity was rediscovered; only two years later Wilson and his students discovered that the cellular basis of Mendelian segregation lies in the separation of maternal and paternal chromosomes in the formation of the germ cells. Again in the year 1905 Stevens and Wilson proved that sex in certain insects is determined by the distribution of two kinds of sex chromosomes to two kinds of spermatozoa; if an egg is fertilized by one of these kinds males are produced; if by the other females result. This solution of the problem of sex determination has been found to be applicable, with certain modifications, to almost every class of animals and plants, thus disposing of one of the oldest and most perplexing problems in the whole realm of biology. Finally on the basis of this work Morgan and his associates, working in close relations with Wilson, have discovered not only the details of "the architecture of the germplasm" but also some of the most important features of the cellular basis of heredity, mutation and evolution. These discoveries represent the high points in the progress of biology in this century, and of all of them Wilson could truthfully say, though his well-known modesty would forbid, "All of which I saw and much of which I was."

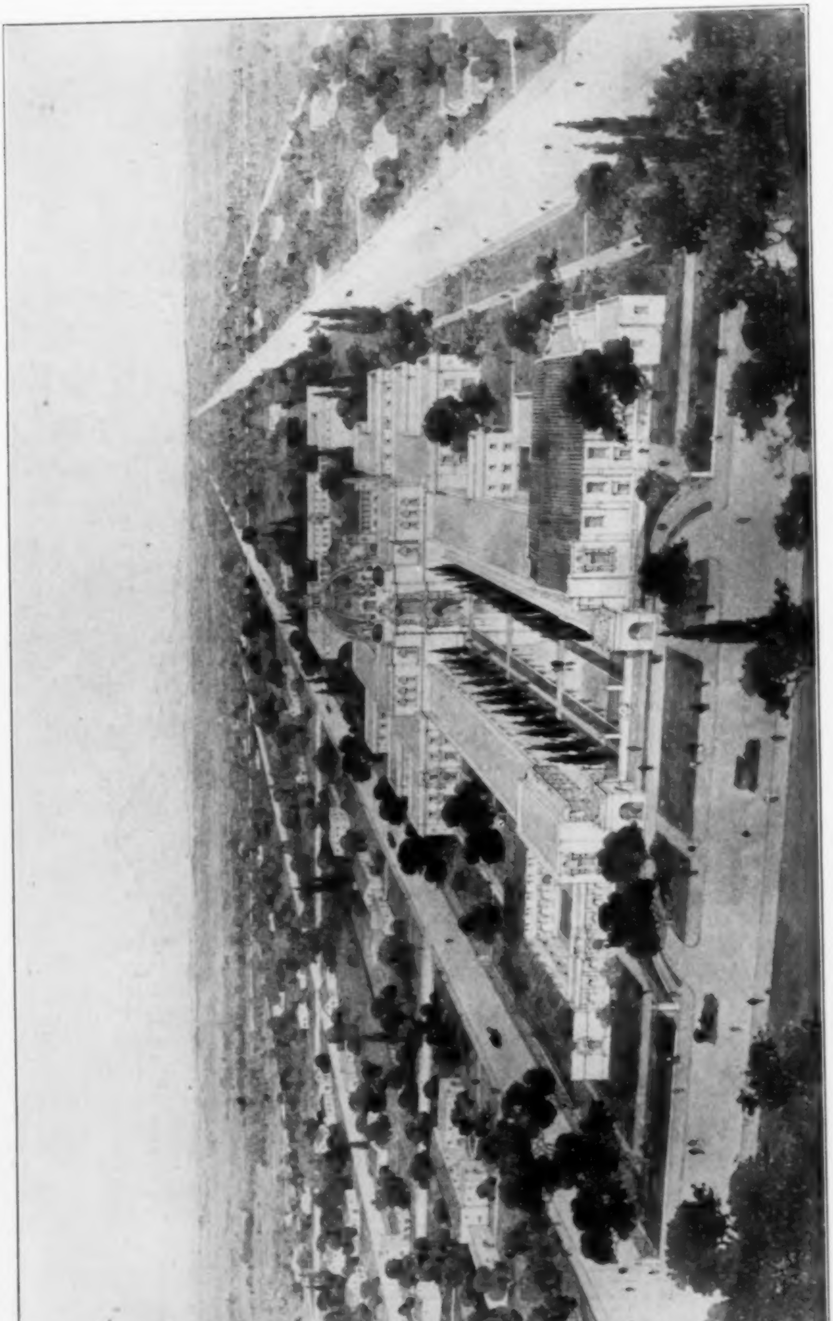
The third edition of "The Cell in Development and Heredity" has been written out of this unique experience; it represents not only the mature point of view of the world's leading student and teacher of cytology, but it is to a large extent the work of its leading investigator in this field. Few other workers are left who were in at the birth of this science and who can speak of its development with the knowledge that comes from intimate contact with persons and problems, and no one could deal with this subject in a more comprehensive and judicial manner. Though called a third edition of the earlier work, this is in reality an entirely new book, rewritten from cover to cover and almost three times as large as the previous edition. It is in every respect a monumental work, one of the most complete and perfect that American science has produced in any field, and while we congratulate Professor Wilson upon this consummation of the work of a lifetime, we are proud of the fact that the National Academy of Sciences can bestow the Elliot Medal on a fellow member for a book of such outstanding worth as "The Cell in Development and Heredity."

THE ASTROPHYSICAL OBSERVATORY OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY

THREE research institutions, working in close cooperation, center in Pasadena: the California Institute of Technology, the Mount Wilson Observatory of the Carnegie Institution of Washington and the Huntington Library and Art Gallery. During the last six years the California Institute and the Mount Wilson Observatory have been conducting a joint attack on the physical, chemical and astronomical aspects of the problem of the constitution of matter, which has resulted in many fundamental advances.

A recent gift to the institute from the International Education Board will permit this attack to be greatly extended, and will provide for an equally wide extension of the various astronomical researches initiated and developed at Mount Wilson. Under the terms of the gift and the approval of their governing boards the Norman Bridge Laboratory of Physics, the Gates Laboratory of Chemistry and the Mount Wilson Observatory will work in the closest cooperation with the new equipment, which will be designed so as to supplement and not to duplicate the instrumental and other facilities already available.

Provision has been made for a 200-inch telescope, with mirror of fused silica instead of glass, to be erected at the most favorable high altitude site that can be found within effective working distance of the cooperating groups of investigators. An astrophysical laboratory, equipped for the measurement, reduction and interpretation of the



BERTRAM GOODHUE'S DESIGN FOR THE CALIFORNIA INSTITUTE OF TECHNOLOGY

THE DESIGN IS BEING FOLLOWED AS CLOSELY AS POSSIBLE. TWELVE BUILDINGS HAVE BEEN PROVIDED FOR. THE NEW ASTROPHYSICAL LABORATORY IS SHOWN.

AIRPLANE VIEW OF THE SUMMIT OF MOUNT WILSON

FROM LEFT TO RIGHT ARE THE SMITHSONIAN ASTROPHYSICAL OBSERVATORY, "MONASTERY," 10-INCH TELESCOPE, POWER HOUSE, LABORATORY, SNOW HORIZONTAL TELESCOPE, SMALLER TOWER TELESCOPE, LARGE TOWER TELESCOPE, 60-INCH TELESCPE AND 100-INCH HOOKER TELESCOPE.

photographic, spectrographic, radiometric and visual observations made with the new telescope, and for various other researches of the joint staff of investigators and the members of a graduate school of astrophysics, will be erected on the campus of the California Institute in Pasadena. The instrument shop will be in a separate building, also on the campus of the institute.

The trustees of the institute have appointed an observatory council, entrusted with the design, construction and operation of the new observatory and laboratory. Its members, chosen from the executive council of the institute, are Robert A. Millikan, Arthur A. Noyes, Henry M. Robinson and George E. Hale (chairman). Through the courtesy of the Carnegie Institution of Washington, Dr. John A. Anderson, of the Mount Wilson Observatory, has been appointed the executive officer of the observatory council, in direct charge of design and construction. In the determination of policy the observatory council will also be assisted by an advisory committee, comprising Dr. Walter S. Adams, director of the Mount Wilson Observatory; Professor Frederick H. Seares, its assistant director; Dr. Charles G. Abbot, secretary of the Smithsonian Institution; Professor A. A. Michelson, of the University of Chicago; Professor Henry Norris Russell, of Princeton University, and Professors Richard C. Tolman, Paul S Epstein and Ira S. Bowen, of the California Institute. Many other astronomers, physicists, chemists, meteorologists, engineers and instrument makers in these and other institutions will be called upon for advice and assistance in connection with the design and construction of the buildings and instruments, and the selection of the best available site for the 200-inch telescope. Special attention will be given to the study and improvement of the auxiliary apparatus and devices required for the registration analysis, measurement and interpretation of celestial phenomena.

In the operation of the telescope the same policy will be maintained which has been followed in the past at the Mount Wilson Observatory and the California Institute of inviting leading authorities in astronomical and astrophysical research to use the 200-inch telescope in the extension of their investigations.